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National Climate Program



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Five-Year Plan 1989-1993

December 1988

U.S. Department of Commerce

NATIONAL CLIMATE PROGRAM OFFICE

**NOAA
11400 Rockville Pike
Rockville, Maryland 20852**

National Climate Program

**Five-Year Plan
1989-1993**

PENNSYLVANIA STATE
UNIVERSITY

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Prepared in the
National Climate Program Office
National Oceanic and Atmospheric Administration

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December 1988

FOREWORD

The Five-Year Plan for the National Climate Program fulfills the need, expressed by Congress, to create a framework for the nation to improve our ability to cope with, understand, and predict climate. The Plan presents broad outlines for program needs over the next few years and enumerates specific goals to be incorporated into plans of participating agencies. Scientists and administrators agree, the tasks ahead are far beyond what can be accomplished in a short time. This Plan recognizes resource and time limitations, and attempts to set realistic priorities. The recommended program will produce early and useful results for the most immediate needs while building the scientific knowledge base required in the longer term.

This Plan covers the fiscal years 1989 to 1993. It sets the goals and objectives for the coming half-decade and summarizes the present status of the U.S. National Climate Program. The most notable accomplishments over the past few years are briefly mentioned. More detailed information can be found in the National Climate Program's Annual Reports to Congress and the President.

The federal government is the sponsor and major participant in the National Climate Program along with the states, the university community, the National Academy of Sciences, and the private sector. This Plan is intended primarily as a guide for government agencies to structure their climate programs, within their individual mission responsibilities. This Plan represents one part of the Nation's effort to understand and respond to Global Environmental Change.

A handwritten signature in dark ink, consisting of a large, stylized 'R' followed by a series of connected loops and a final horizontal stroke.

Robert A. Mosbacher
Secretary of Commerce

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EXECUTIVE SUMMARY

“It is the purpose of the Congress in this Act to establish a National Climate Program that will assist the Nation and the world to understand and respond to natural and man-induced climate processes and their implications ... The National Climate Program Office shall be the lead entity responsible for administering the Program ... Each Federal officer, employee, department and agency involved in the Program shall cooperate with the Secretary of Commerce in carrying out the provisions of this Act ... The National Climate Program Office shall work with the National Academy of Sciences and other private, academic, State, and local groups in preparing and implementing the 5-year Plan and the Program ... ”

Taken from the National Climate Program Act

BACKGROUND

The National Climate Program Act (see Appendix A) directs the periodic formulation of a new Five-Year Plan for the program. The first Five-Year Plan covered the years 1979 to 1984. An interim plan was written to cover the period 1984 through 1986. This Five-Year Plan provides a framework for planning and actions for fiscal years 1989 to 1993. The Plan builds on the experience gained since the program's inception in 1978, on a review of the National Climate Program (NCP) conducted by the National Academy of Sciences in 1985, on interactions between the programs of participating U.S. government agencies and institutions, and on the World Climate Programme.

Many recent events have served to focus public attention and concern on climate and its variability:

- An extreme El Nino event in 1982-83 may have contributed to reduced fish catches, surf damage along coastlines from South America to California, and changes in worldwide rainfall patterns, causing floods along the West coast of South America and droughts in Asia.
- Recurrent drought in the African Sahel and East Africa and an associated famine triggered massive international relief efforts in 1984-85.
- Water levels in the Great Lakes and the Great Salt Lake reached record highs, causing soil erosion, flooding, and the loss of agricultural land, homes, and businesses.

- Many believe that the apparent 0.5 degree Celsius global warming over the past century may be partially related to atmospheric increases in CO₂ and other trace gases.
- Concern has been raised at the observed decrease in the amount of stratospheric ozone over Antarctica and the world in general during the past decade and its relationship to the increased global use of chlorofluorocarbons.

Not all climate fluctuations are bad, however. Atlantic hurricane frequencies have been below normal for six of the last eight years, and several mild winters have recently helped ameliorate the burden of heating costs.

Several other significant activities related to the National Climate Program have taken place recently:

- A Congressional request to the Environmental Protection Agency calls for an analysis of the potential impact of climate change caused by increased levels of CO₂ and other trace gases, and on stratospheric ozone depletion.
- International agreement has been reached on regulating the emission of substances that deplete the stratospheric ozone layer (the Montreal Protocol).
- The World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) agreed in 1987 to establish an intergovernmental Panel for carrying out internationally coordinated assessments of the magnitude, timing, and potential impact of climate change.
- A joint communique from the December 1987 US-USSR Summit pledged both countries to pursue joint studies in global climate and environmental change through cooperation in areas of mutual concern, such as protection and conservation of atmospheric ozone and through increased data exchanges.

Over the next decade, national and international attention on issues of global climate change will likely increase. This document provides a plan for federal agencies to address this challenge by developing an improved understanding of climate change and its likely impacts on society.

STRATEGY UNDERLYING THE FIVE-YEAR PLAN

The primary goal of the National Climate Program is to understand and predict natural and man-induced climatic

change and its variation. Climate is often viewed as a "national resource". Strategies for adapting to natural variability are a key component of the program. There is mounting evidence that the chemical composition of the Earth's atmosphere is being influenced by man's activities. Although we do not fully understand these processes, it is believed that this may lead to a global warming within the next few decades. In order to assess the full implications of these changes, activities of the National Climate Program over the next five years will focus on the following three problem areas:

- (i) Accurate diagnosis of the current state of the entire climate system and the factors having an influence on climate, to detect any changes in the current state of the climate system.

This will require concentrated efforts to develop an efficient, operational climate monitoring system using recent advances in observational technology for both in situ and remote sensing, and to implement a comprehensive climate data management and analysis system. Special emphasis must also be given to establishing an accurate data base for measuring and analyzing changes in climate caused by man's activities.

- (ii) Exploration of the predictability of climate on time scales of months to decades, and the projection of a climatic change caused by an increasing concentration of greenhouse gases.

For all time scales, more realistic models of the dynamic and thermodynamic coupling between the oceanic and atmospheric components of the climate system need to be developed. Improved parameterization schemes for cloud radiation interactions and ice albedo are required. Considerable research efforts are also needed with regard to the treatment of the exchange processes between the atmosphere, the ocean and the land surface, including the biosphere, and cryospheric processes. In addition to research, progress in the development of more reliable climate models is critically dependent on the organization of large-scale observational programs to provide the data needed.

- (iii) Assessment of the impact of a greenhouse gas-induced climatic change on the environment, and analysis as to what policy decisions can be taken in order to reduce harmful consequences.

This will require research on both evaluating to what extent increased emissions of greenhouse gases modify the atmosphere's radiation balance, and how a resulting climatic change might influence natural ecosystems and human activities (e.g., agriculture, forestry, water resource management, and energy production).

MAIN COMPONENTS OF THE NATIONAL CLIMATE PROGRAM

Based on this strategy, the National Climate Program (NCP) Plan has been structured to contain three main components:

Climate Data, Analysis, and Services

This component is designed to create an easily accessible knowledge base of up-to-date data and information for general use in describing and understanding climate and its variations. Over the next five years, the emphasis in this element will be on establishing an efficient and reliable system for long-term monitoring of the climate system, and making climate data and information more readily available through improved climate data services.

This is especially important since the volume of weather and climate data over the next few years (from new satellites, new automatic weather observing systems, international research projects, and other sources) is expected to increase about 1000 times over what is presently available. This massive increase will require a coordinated and effective process of data handling and storage.

The on-going change of the atmospheric concentration of radiatively important trace species (e.g. carbon dioxide, chlorofluorocarbons, nitrous oxide, methane, and tropospheric ozone) may have a significant influence on climate. There are, however, considerable uncertainties as to the magnitude and timing of such greenhouse-gas-induced climatic changes. Special attention must therefore be given to the preparation of more accurate analyses of past climatic changes and present trends, as well as research aimed at understanding the causes for these changes, including the development of improved knowledge about the sources and sinks, and the biogeochemical cycling of the major greenhouse gases.

Climate Modeling and Prediction

This component is designed to improve our basic understanding of the climate system and our ability to predict possible or likely changes in climate. Over the next five years, national projects (coordinated with international efforts where possible) which advance the understanding of climate predictability on all time scales will be emphasized.

Recently, it has become evident that, under certain conditions, probabilistic climate forecasts on the order of weeks to months are possible. Qualitative interannual forecasts may also be possible for periods in which El Nino events occur.

Research related to climate prediction is organized in the same way as the International World Climate Research Programme, i.e., into three different categories (Streams 1, 2, and 3), each one corresponding to a specific time scale and research objective.

- Establishing the physical basis for prediction over periods of one month to a season (Stream 1).
- Evaluation of the predictable aspects of global climate variations over periods up to several years (Stream 2).
- Characterization of climate variations and change over periods of decades and longer (Stream 3).

The same physical processes are often involved in climate

prediction on all these time scales. Improvement in prediction on one time scale therefore can contribute to improvements on the others as well.

This component will also include the preparation of internally consistent representations of climatic change caused by an increased concentration of greenhouse gases, presented in sufficient detail to be useful for climatic change impact studies.

The Impact of Climatic Change on the Environment

Numerous assessments of the possible impacts on the environment caused by a greenhouse-gas-induced climate warming have been carried out during the past decade, both nationally and internationally, considerable knowledge having been gained. Nevertheless, there are still many uncertainties, particularly with regard to how, and to what degree, this change in the composition of the atmosphere will modify the climate, globally and regionally, and how this in turn will affect natural and anthropogenic ecosystems.

Over the next few years, a well-coordinated research and assessment program is needed to provide a scientific basis for the formulation of a national response to a greenhouse gas-induced climatic change. Major priorities include:

- Assessment of the consequences of a climatic change on natural and managed ecosystems, including, e.g., agriculture, forestry, water resources, energy demand and supply, as well as the consequences of a rise in the sea level.
- Development of methodologies for comprehensive integrated assessments of the impact of a climatic change in selected vulnerable regions, taking into account biological, economic, and social circumstances.
- Development of strategies and policy options for limiting the levels of the emissions of greenhouse gases, and methods for adjustment of human activities to climatic change.

Over the next two years an international assessment of climate and its impact on society will be organized by WMO and UNEP through the newly created Intergovernmental Panel on Climate Change (IPCC). The U.S. will be a major contributor to the work of this Panel, and will chair the working group on response strategies.

PROGRAM IMPLEMENTATION

Implementation of the National Climate Program is a cooperative endeavor among federal and state agencies, regional and private institutions, academia, and the private sector, and is coordinated by the National Climate Program Office (NCPO) with scientific guidance from the National Academy of Sciences (NAS) and programmatic review by the Climate Program Policy Board. This Board established

by legislation, is the forum for federal agencies to discuss and formulate commitments to the national and international climate programs. Additional coordination with other earth and geophysical science programs is provided through the Committee on Earth Sciences (CES).

Current broad agency responsibilities within the NCP are defined below:

- DOE: Lead agency for study of carbon dioxide and climate.
- DOS: Coordination and policy setting for U.S. participation in international programs.
- EPA: Assessing impacts of climate change on environmental quality (see Appendix B).
- NASA: Responsible for developing remote sensing techniques to study Earth as an integrated system. Lead agency for coordination of ozone program.
- NOAA: Lead agency for coordination of the National Climate Program. Responsible for monitoring, archiving, and disseminating atmospheric and oceanic data. Lead agency for climate prediction.
- NSF: Support of basic research in all aspects of the NCP. Lead agency for the U.S. Antarctic Program and for coordinating activities related to the Arctic Research and Policy Act of 1984.
- USDA: Evaluation of the role of climatic change and variability on agricultural (food and fiber) systems.
- USGS: Lead agency for study of interaction between climate and hydrology, and a major participant in studies of paleoclimate, including the reconstruction of Pliocene climates.

It is not feasible to identify or highlight every type of climate activity in this Plan. The nation should maintain a certain level of basic climate research in areas not mentioned specifically in this Plan, such as solar-terrestrial studies and planetary science, from which new insights may be gained and unexpected climatic events might be interpreted.

Not all federal agencies involved with the National Climate Program are actively managing parts of the program. Some agencies, such as HHS, HUD, Justice, DOT, and Treasury, primarily depend on the results and progress of the national program. Over the next five years, it is important that federal agencies play an active role in ensuring that the implementation of the program is to their benefit, i.e., that the lead and participating agencies for each program component are producing results that are useful to all.

The National Academy of Sciences provides scientific guidance to the federal agencies participating in the program, primarily through the activities of the Board on Atmospheric Sciences and Climate (BASC), the Ocean Studies Board (OSB), and other related activities of the National Research Council (NRC). As the U.S. representative to the Interna-

tional Council of Scientific Unions, (ICSU), the Academy also serves as a nongovernmental interface with the international scientific community. For example, the Climate Research Committee of BASC acts as the U.S. National Committee for the WMO/ICSU World Climate Research Programme; the NAS's Ocean Studies Board serves as the U.S. National Committee for the ICSU's Scientific Committee on Oceanic Research (SCOR) which, together with the IOC, sponsors the Committee on Climatic Changes and the Ocean (CCCO).

NCPO is the lead entity responsible for administering the Program. It has the authority for coordinating the development of a research agenda for the federal government in the area of climate research and assessment pursuant to the National Climate Program Act.

Management functions of the NCPO include planning, coordination, program evaluation, and reporting, through the Secretary of Commerce, to the Executive Branch and U.S. Congress. Additional Program responsibilities specifically mandated by the Act cover intergovernmental climate activities, development of experimental forecast centers, and coordination of international aspects of the National Climate Program.

EXPECTED ACCOMPLISHMENTS OVER THE NEXT FIVE YEARS

Many of the scientific problems connected with research aimed at understanding the processes governing the climate system are exceedingly complex and it is apparent that they cannot be expected to be solved within such a short time period as five years. This is also true with regard to the analysis of the consequences of a climatic change on natural and managed ecosystems and its links with other environmental problems.

However, what can be accomplished over the next five years is the organization of a dedicated effort to develop a long-term monitoring system to provide the data necessary for climate research and applications. It is also imperative to begin developing preliminary assessments of the impacts of a climatic change on society to ensure that as little time as possible is lost if steps are necessary to minimize the causes of the climatic change and/or development of adjustment strategies.

The following accomplishments are anticipated over the next five years (not given in order of priority):

Climate Data and Services:

- Improved dissemination of data required for climate research, and for improving private sector access to climate information.
- Improvement of global-based observing systems, taking advantage of new technologies for observing and communicating meteorological and oceanographic data,

including satellites and other remote sensing capabilities.

- Completion of the planning of a comprehensive monitoring and delivery system for the assessment of the state of the Earth's climate.

Climate Modeling and Prediction:

- Development of more realistic schemes for representation of physical processes and feedback mechanisms in climate models.
- Implementation of U.S. commitments to the World Climate Programme, specifically Climate Computer System (CLICOM), International Satellite Cloud Climatology Project (ISCCP), International Satellite Land-Surface Climatology Project (ISLSCP), Tropical Ocean and Global Atmosphere (TOGA), and the Trace Gas Program, as well as the Montreal Protocol on the regulation of the emission of substances that deplete the ozone layer.
- Completion of planning for and beginning of the implementation of a U.S. program for the World Ocean Circulation Experiment (WOCE).
- Development and evaluation of more realistic climate models and historic case studies to evaluate possible future climatic change.
- Development of an arctic climate studies program as part of the U.S. Arctic Research Plan.
- Improved models for forecasting emissions and the atmospheric concentration of radiatively important trace substances.

Impacts of Climatic Change on the Environment:

- Improved knowledge of the consequences of a climatic change on natural and human ecosystems.
- Initiation of a national program to address climatic aspects of water resource issues.
- Analysis of policy options to affect the future levels of emissions of radiatively important trace substances, and of options to adjust to climatic changes.

MAJOR REPORTS

The Global Climate Protection Act of 1987 (P.L. 100-204) directs the Secretary of State and the Administrator of EPA to report to Congress summarizing the international scientific understanding of the greenhouse effect and its possible environmental impacts, and to outline a strategy by which the U.S. intends to seek further international cooperation to limit global climatic change.

The preparation of this report will be coordinated by the Department of State and EPA with other involved agencies through the Committee on Earth Sciences, and the NCP Policy Board.

THE NATIONAL CLIMATE PROGRAM AND INTERNATIONAL ACTIVITIES

The needs of the National Climate Program cannot be met by observational and research efforts restrained by national boundaries, nor can our needs for global data be satisfied solely by observations taken by satellites, ships, planes, and ground stations under direct U.S. control. We depend heavily on the free international flow of meteorological data, not only for weather forecasting, but also for the development of climate products.

The World Climate Programme

The World Climate Programme (WCP) was formed in 1979 to coordinate international, climate-related activities. The WCP is administered by the World Meteorological Organization, with active participation by the United Nations Environment Program, the Intergovernmental Oceanographic Commission, and the International Council of Scientific Unions, specifically the Scientific Committee on Ocean Research, the Scientific Committee on Antarctic Research, and the Scientific Committee on Problems of the Environment.

The World Climate Programme is divided into four components: World Climate Data Programme (WCDP), World Climate Applications Programme (WCAP), World Climate Research Programme (WCRP), and World Climate Impact Studies Programme (WCIP). To a large extent, the World Climate Programme is thus structured in a similar way as the National Climate Program (except that the data and applications activities are combined into one component in the NCP), which has proven to be to the advantage of both programs; it facilitates coordination and it provides better opportunities for sharing resources.

The U.S. participates in many international observational projects being organized within the World Climate Research Programme (WCRP), e.g., the Tropical Ocean Global Atmosphere Project, the World Ocean Circulation Experiment, the International Satellite Cloud Climatology Project, and the International Satellite Land Surface Climatology Project, and the development of a climate computer system to assist nations in better organizing and using climate data and information.

The International Geosphere-Biosphere Programme

In 1986 the International Council of Scientific Unions endorsed a new international program, the International Geosphere-Biosphere Programme (IGBP): A Study of Global Change, with the objective of describing and understanding the interactive physical, chemical, and biological processes that regulate the total Earth system.

Given such an encompassing focus, reaching from the interior of the Earth to the center of the Sun, it shares the interests of other more well-defined international programs such as the World Climate Research Programme. However, in order to avoid unnecessary duplication of efforts, the IGBP will put less emphasis on studies that are already being addressed in existing programs.

Consequently, excellent opportunities exist to proceed with the implementation of the WCRP and planning the activities of the IGBP in such a way that the two international programs effectively complement each other. In fact, given the substantial achievements already accomplished by the WCRP, not least with regard to observational programs relating to the individual components of the climate system, the WCRP can serve as a building block for the further development of the IGBP.

The U.S. Global Change Program

Preliminary planning for the U.S. contribution to the International Geosphere-Biosphere Program — A Study of Global Change has already taken place within the National Academy of Sciences, which has appointed a Committee on Global Change, that will also serve as the U.S. National Committee for the IGBP.

Several Federal agencies have responded to this international initiative and are formulating research and observational programs within the framework of the general concept of global change.

The National Science Foundation, for example, has established a Global Geosciences Program; NASA's Science Advisory Council has developed a program for an ambitious study of global change, named Earth System Science; NOAA has prepared a program called Climate and Global Change. All of these programs rely heavily on active climate research and data collection activities. Other agencies, like DOE, EPA and USGS, are also formulating programs to contribute to the IGBP.

To coordinate the U.S. activities related to the international "global change" program, the President's Science Advisor has established a Committee on Earth Sciences under the Federal Coordinating Council for Science, Engineering and Technology (FCCSET), which, among other responsibilities, is charged with the task of coordinating agency research programs in earth sciences, including national and international programs.

Research on Ozone Depletion

The Coordinating Committee on the Ozone Layer (CCOL) was formed by UNEP in 1977, and consists of international, governmental, and nongovernmental representatives. In the U.S., NASA provides the leadership in coordinating national and international efforts, working closely with EPA, NOAA,

NSF and other agencies. An international assessment of ozone changes, including its impacts on climate, has been published (WMO, 1986). International agreements have been adopted under UNEP auspices providing for research and for reductions in emissions of ozone-depleting substances.

Many agencies involved in the ozone research program, particularly in monitoring atmospheric chemistry and modeling, are also involved in the NCP. Coordination in conjunction with the Interagency Committee for Stratospheric Ozone Protection (ICSOP) of future ozone and climate research programs has been initiated.

BUDGET

The President's FY 1989 budget requests approximately 230 million dollars for agency programs in support of the NCP goals. Specific breakdown of this funding by agency is given in the budget section of this report.

Traditionally, funding for the NCP has been divided into three basic categories: monitoring and data management, climate modeling and prediction, and climate change impacts.

Costs for monitoring and data management systems are in part incomplete because each satellite system or data management center may serve many climate and geophysical functions. Thus, major costs for satellite systems are not included in these totals.

"The (National Climate Program) Act ... was meant to be an experimental prototype for the organization of research that crosses agency and interdisciplinary boundaries. The Conference Report to the 1978 Act stated that the entire point of making climate the focus of a national program is to emphasize that it is a subject which cannot be confined in ordinary organizational boundaries, and that it must be considered as a critical element of strategic planning in almost

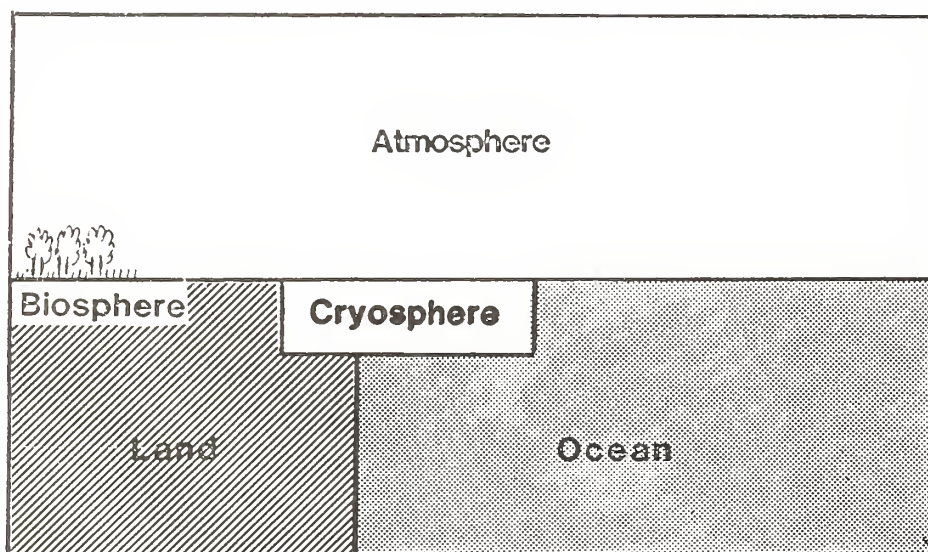
all areas of human endeavor. Judging by the progress which has been made in the last seven years, I would say that the intent of the 1978 Act has been carried out."

George E. Brown, Jr.
Member of Congress
(1986)

The climate system includes the following components (WCRP, 1984):

- *The atmosphere*, which is the most rapidly variable part of the system. The troposphere has a characteristic response or thermal adjustment time on the order of one week, while the stratosphere and higher layers of the atmosphere have quite different processes and time scales.
- *The ocean*, which interacts with the overlying atmosphere or ice on time scales of months to years, while the deeper ocean has a thermal adjustment time on the order of decades to centuries.
- *The cryosphere*, which comprises the continental ice sheets, mountain glaciers, sea ice, surface snow cover, and permafrost zones. The changes of snow cover and the extent of sea ice show large seasonal variations while the glaciers and ice sheets respond much more slowly.
- *The land surface*, which comprises the land masses of the continents, including the lakes, rivers, and groundwater, which are important components of the hydrological cycle. These are variable components of the climate system at all time scales.
- *The biosphere*, which is the collective term for all living and dead organic matter in our environment. The fraction of the biosphere which is most significant for shaping climate on seasonal to decadal time scales is the terrestrial vegetation, while phytoplankton in the upper ocean is a deciding factor on longer time scales.

THE CLIMATE SYSTEM



1. INTRODUCTION

1.1 Background

It is to the credit of the architects of the National Climate Program Act that in 1989, eleven years after its passage, it is still not only timely, but also gaining increasing importance.

The world meteorological and oceanographic community is implementing the World Climate Programme (WCP). National and international attention is gradually turning to issues of actual and potential socioeconomic consequences induced by the vagaries of climate and concerns about the possible modification of climate by human activities.

Extreme weather and climate events in recent years, and their socio-economic consequences, have forcibly reminded us that atmospheric variability is not just an interesting dynamic feature of our environment. Figure 1 shows the global extent of extreme climate conditions, including a pronounced El Nino event, during 1982-1983. While many technical ad-

vances have served to insulate us from the normal variability of nature, the impacts of extreme conditions remain. The more interconnected the world becomes, especially through trade and foreign aid (see Figure 2), and the more capital investments that are made in natural resource utilization, the larger the penalties are for neglect, mismanagement, and misjudgment of the environment; and conversely, the greater the rewards are for careful analysis and planning.

The pervasiveness of drought conditions in Africa, two major El Nino, Southern Oscillation (ENSO) events (1976 and 1982-83), the volatility of international market conditions during food surpluses and deficits, the rise in the water levels of the Great Salt Lake and the Great Lakes (Figure 3), worldwide depletion of stratospheric ozone, and the recognition that man's activities may contribute to climatic changes, have all recently been topics of public concern. They underscore the importance of further efforts to understand the causes and anticipate the occurrence of major climate fluctuations and long-term changes.

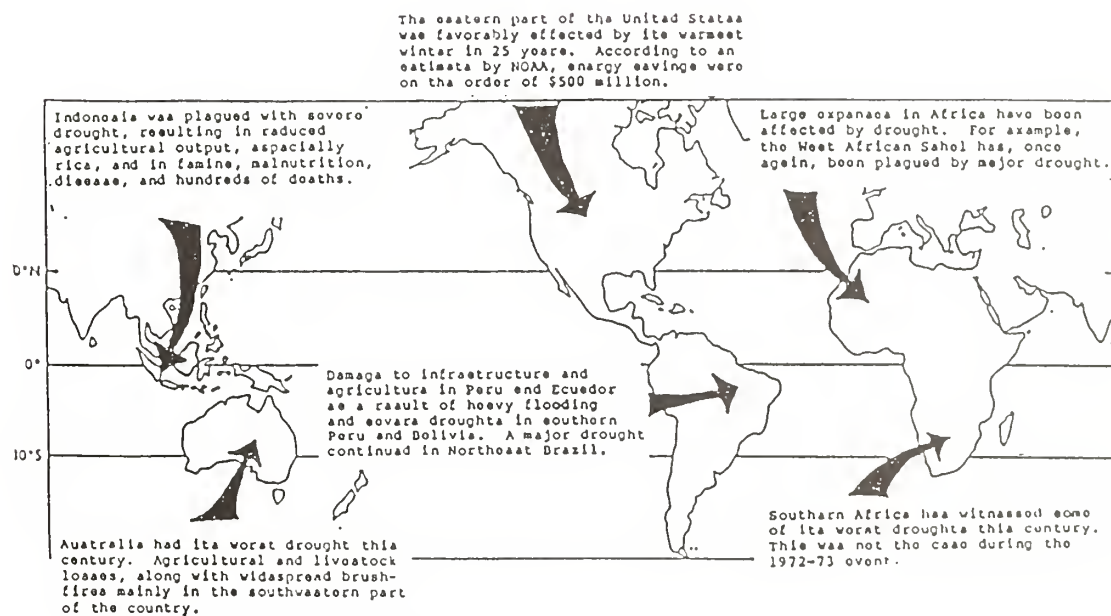


Figure 1. Worldwide climate impacts during 1982-1983 (from Glantz, 1986).

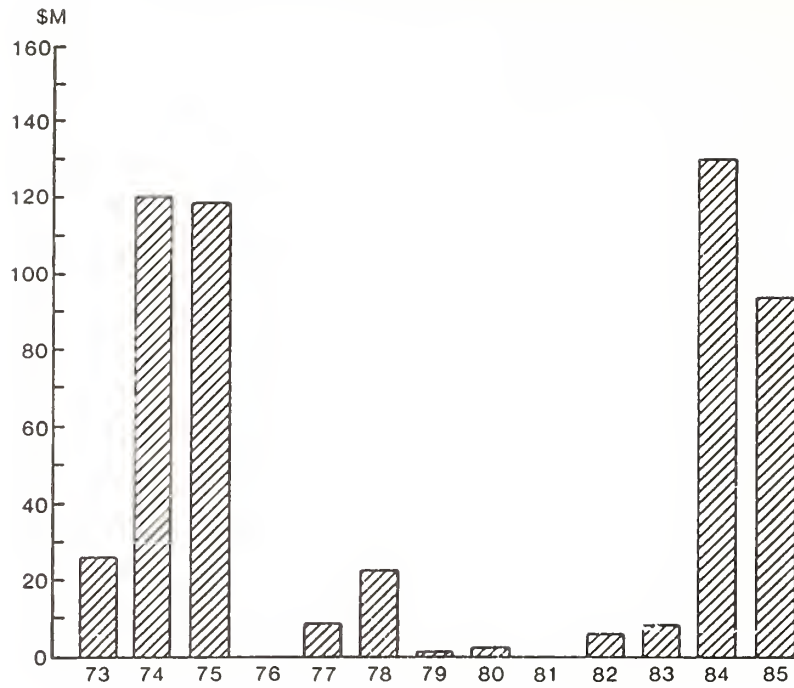


Figure 2. U.S. AID assistance to African nations for drought relief from FY73 to FY85 in millions of dollars.

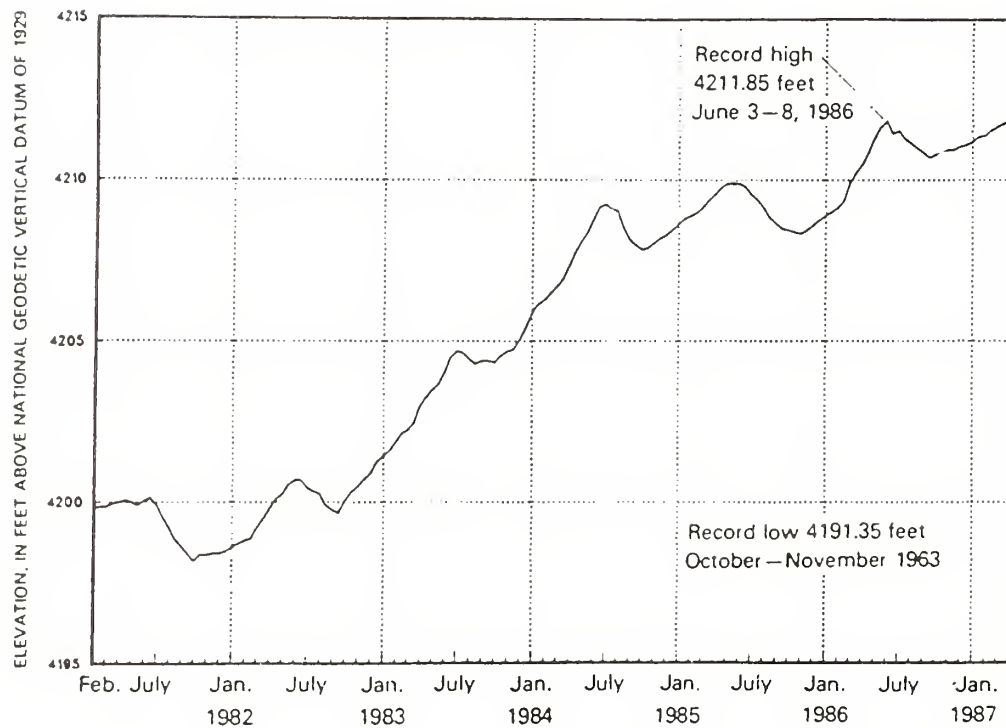


Figure 3. Fluctuations in the water level of the Great Salt Lake, February 1981 to April 1987 (USGS and Department of Environment, Canada, 1987).

1.2 Accomplishments and Perspectives

Since the National Climate Program began, progress has been made in a number of important areas:

- Major advances in observing the ocean and modeling its circulation are beginning to occur. New space-based instruments for ocean observations, the availability of advanced computational resources, and the realization of the importance of the oceans as a natural resource and their crucial role in understanding and predicting global climate are coming together so that, in the near future, major insights into three-dimensional ocean circulation will be possible. Figure 4 shows an example of the close agreement which can be obtained between satellite-observed sea level data and those observed in situ.

- An in-depth assessment by the DOE of what is known about the physical, geochemical, and ecological ramifications of atmospheric CO_2 changes has been completed. The growth in concentrations of CO_2 since the 1700's is presented in Figure 5.
- Advances in understanding the role of a number of trace gas constituents has led to concern about their potential impact on the basic chemistry of the atmosphere as well as their combined contribution to global climate change. Efforts are continuing to identify their global sources and sinks, and to understand their interactions and effects (see Figure 6 and Table 1).
- Improvements have occurred in understanding climate processes through paleoclimate studies which combine climate models and paleorecords to reconstruct past climates. One example, for 9000 years before present, is presented in Figure 7.

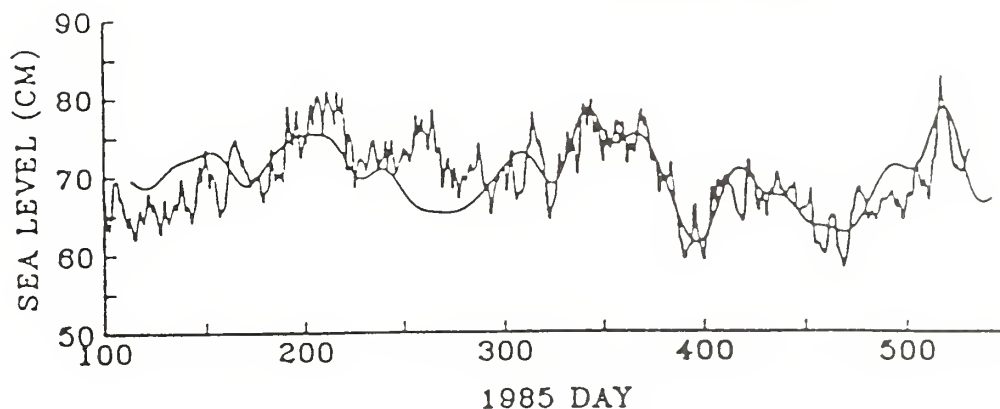


Figure 4. Comparison of GEOSAT altimeter-derived heights of the sea level (the smooth curve) at Christmas Island in the equatorial Pacific with in situ tide gauge measurements during a 14-month period (April 1985-June 1986 (Cheney et al. 1986).

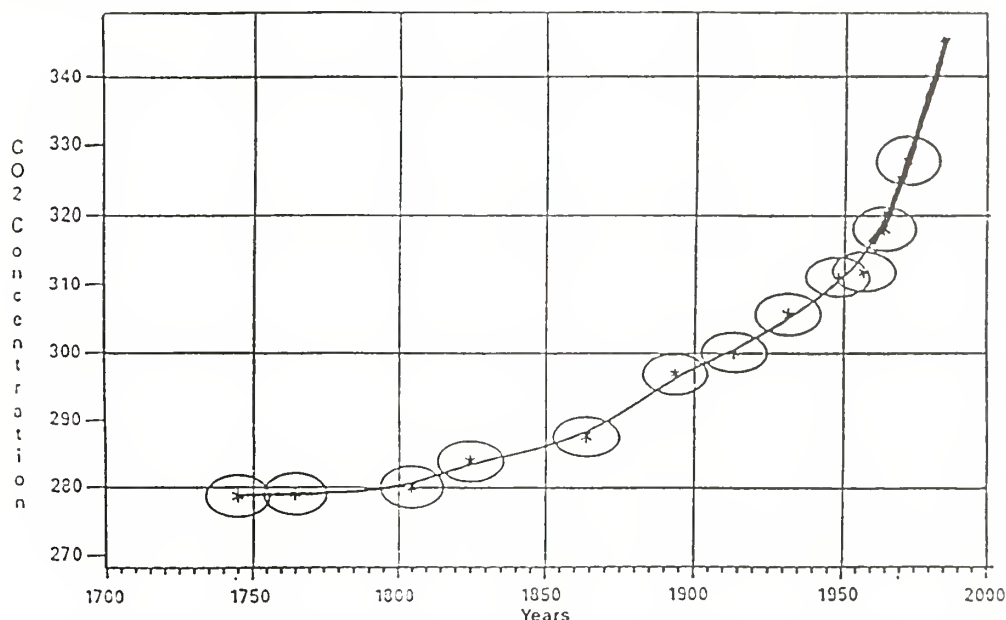


Figure 5. Variations in the atmospheric concentrations (in ppmv) of carbon dioxide with time. The thin line represents the concentration measured in glacier ice during the last 200 years (Source Neftel et al., 1985). The thick line gives the concentration measured at the Mauna Loa Observatory, Hawaii, since 1958.

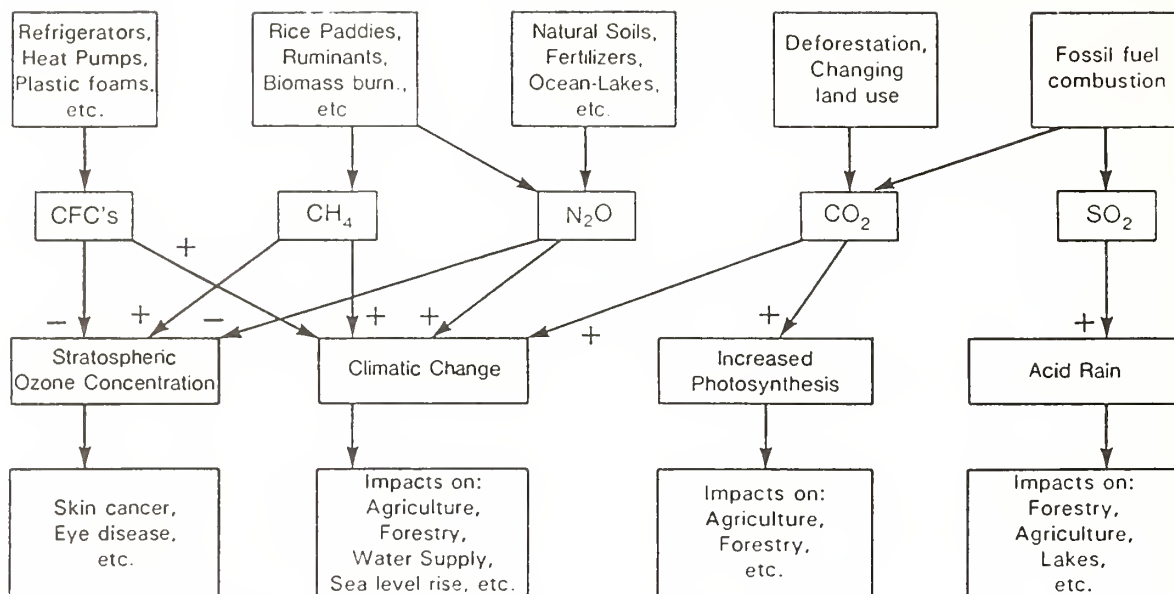


Figure 6. A simplified diagram indicating the consequences of the changing (natural or man-made) composition of the atmosphere. The plus and minus signs indicate whether an increase of the atmospheric concentration of a trace gas intensifies or reduces the various types of impacts.

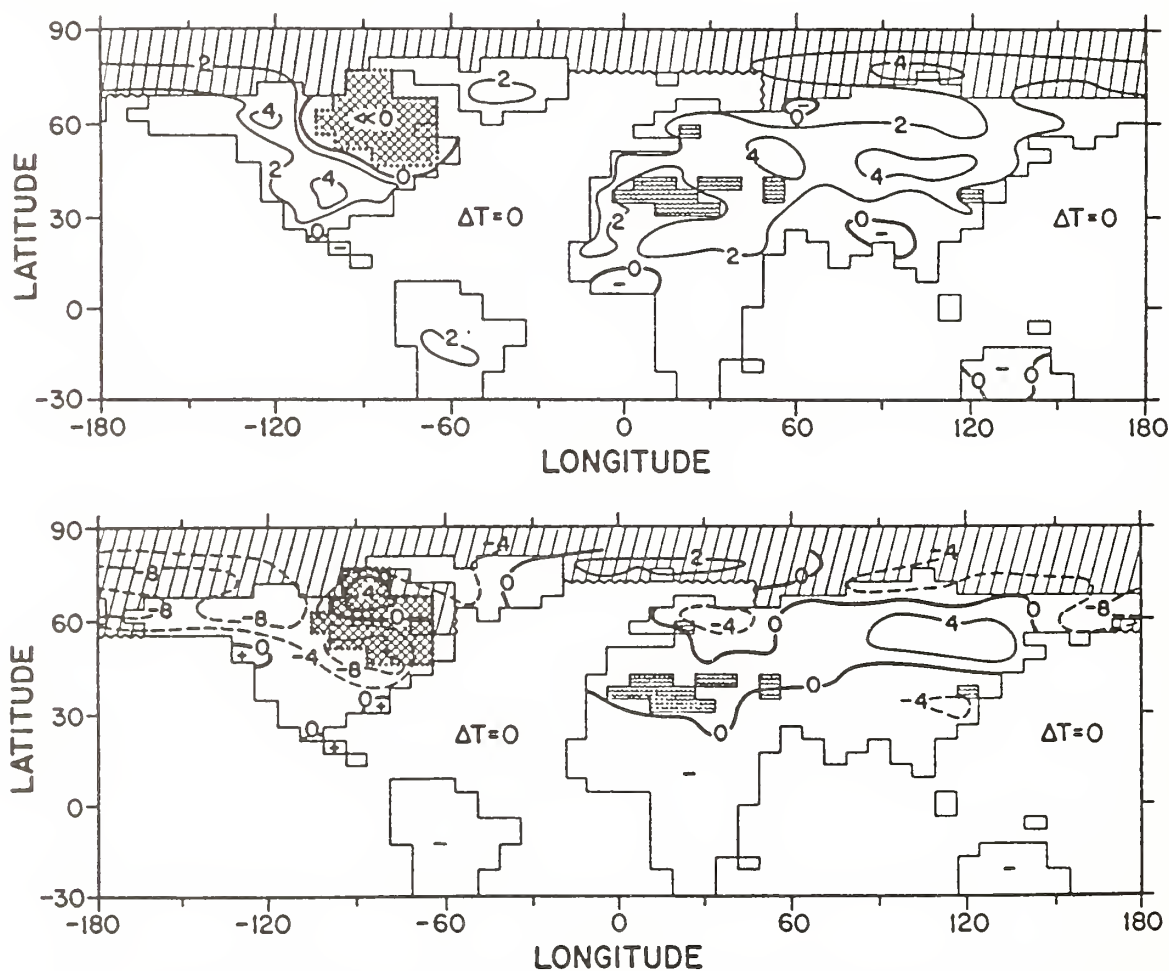


Figure 7. Simulated land surface temperature differences in degrees Celsius (9000 years BP minus present) for July (upper figure) and January (lower figure). The computations were carried out with North American ice sheet (hatched) and present ocean temperatures (Kutzbach and Guetter, 1984).

- Significant improvements are occurring in the climate service system (collecting, archiving, and disseminating climate information). National, regional, and local efforts are being made to address the needs of the farmer, the business person, and the politician for accurate and timely climate information, and internationally, to help less developed countries use and expand their observing networks.

As an example, Figure 8 shows a data system which is automated and operating in Nebraska and surrounding states to provide recent weather and climate information required for agricultural activities.

- New methodologies for climate impact assessment have been developed both nationally and internationally.
- First steps have been taken toward gathering international commitments for implementing the World Climate Research Programme (NCPO Annual Report, 1986).

1.3 Structure of the National Climate Program

Based on the strategy outlined in the Overview, the National Climate Program has been structured to contain three main components (see Figure 9). *The first and most crucial component is comprehensive and well-organized monitoring of the climate system.* This requires a well-coordinated international program aimed at improving many components of the meteorological and climatological data information system, as well as archiving the data permitting easy access to the information for different purposes.

The second component of the NCP aims to improve understanding of the many physical processes which govern the climate, and to develop climate models for (a) prediction of weather anomalies for periods up to a season, (b) prediction of large-scale variations of the global climate for periods up to several years, and (c) characterization of vari-

TABLE 1.
Changes in Surface Temperatures for Different Levels of Atmospheric Trace Gases, Using Climate Models (Wang et al., 1986).

Chemical	Sensitivity Study	Change in Surface Temperature (°C)
CO ₂	330 → 600 ppm	+1.5 to +4.5
CH ₄	1.7 → 3.4 ppm	+0.2 to +0.4
CFCl ₃ CF ₂ Cl ₂	Constant emissions at 1977 rates: 0 → 1.0 ppb, CFCl ₃ ; 0 → 2.7 ppb, CF ₂ Cl ₂	+0.5
	Constant emissions at double 1986 rates: 0 → 1.8 ppb, CFCl ₃ ; 0 → 5.0 ppb, CF ₂ Cl ₂ ; 0 → 1.5 ppb, CH ₃ CCl ₃	+1.0
N ₂ O	0.3 → 0.6 ppm	+0.3 to +0.4
O ₃	2 × Tropospheric distribution	0.9
H ₂ O	Stratosphere 3 → 6 ppm	0.6

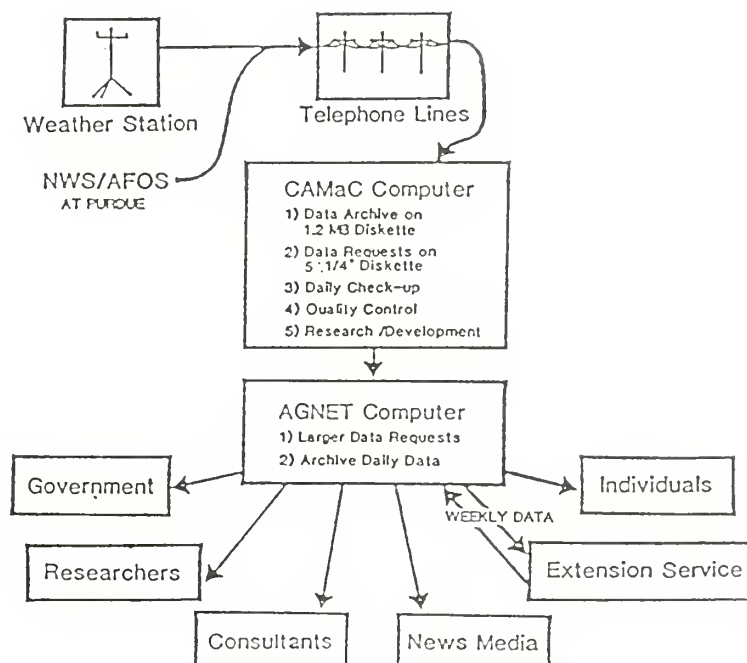


Figure 8. Data and information flow of the Automated Weather Data Network (AWDN) and the Agricultural Management Network (AGNET) in Nebraska (Hubbard et al., 1983).

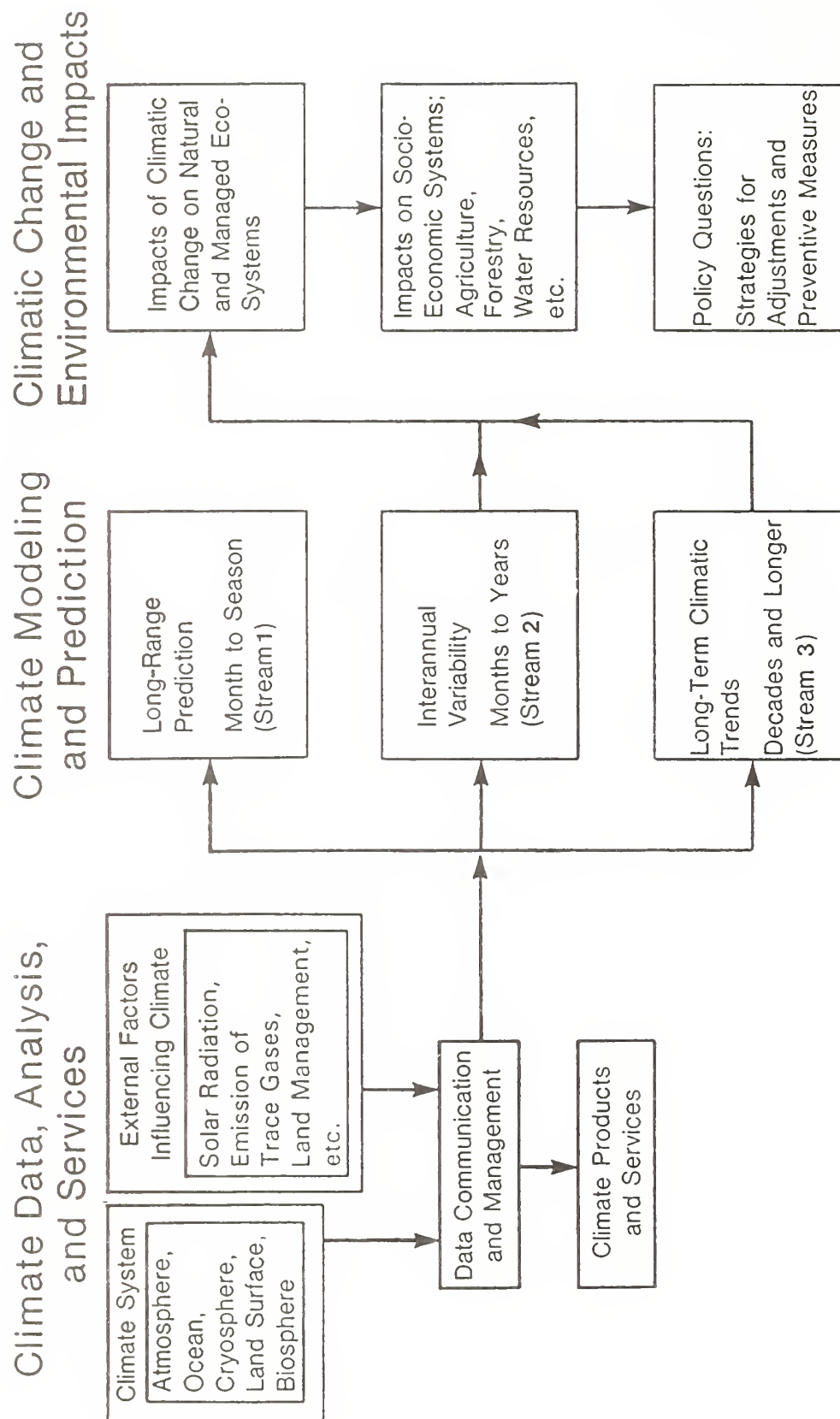


Figure 9. Schematic illustration of the main components of National Climate Program.

ations and change of climate on a decadal time scale caused by natural or man-made influences.

The third component of the NCP is directed toward understanding the consequences of a greenhouse gas-induced climatic change for natural and managed ecosystems, including agriculture, forestry, coastal zones, fisheries, water resources, and energy demand and supply. In addition, this component includes the development of strategies for adjusting to a changing climate as well as the feasibility of reducing a further build up of atmospheric concentrations of radiatively important gases.

1.4 International Scientific Programs Related to the National Climate Program

Coordination of U.S. involvement with international climate activities continues to be centered around the World Climate Programme organized and led by the World Meteorological Organization (WMO), the International Council of Scientific Unions (ICSU), and the United Nations Environment Programme (UNEP). In addition, the United States is actively engaged in bilateral climate programs, particularly with Brazil, Canada, China, France, India, Spain and the Soviet Union.

Excellent opportunities also exist for mutually beneficial cooperation with the newly established International Geosphere Biosphere Programme (IGBP).

1.4.1 The World Climate Programme

The World Climate Programme (WCP) is administered by the World Meteorological Organization (WMO) for the following purposes:

- (i) To aid countries in the application of climatic knowledge to benefit the planning and management of many aspects of man's activities.
- (ii) To foresee and warn of possible future variations and changes in climate, either natural or man-made, which may significantly affect the economic and social activities of mankind.

The WCP is composed of four components — data, applications, impact studies, and research. The WMO is responsible for the overall coordination of the WCP and for the data and applications components. The United Nations Environment Programme has accepted the responsibility to implement the impact studies component. The research component is being jointly implemented by ICSU and WMO.

1.4.2 The International Geosphere-Biosphere Programme: A Study of Global Change

In 1986 the General Assembly of the International Council of Scientific Unions (ICSU) endorsed the establishment of a research program named the International Geosphere-Biosphere Programme (IGBP): A Study of Global Change.

It will be directed at providing the information we need to assess the future of the Earth in the next 100 years.

The objective of the program is to describe and understand the interactive physical, chemical, and biological processes that regulate the total Earth system, the unique environment that it provides for life, the changes that are occurring in this system, and the manner in which they are influenced by human actions.

The program is being planned in two phases:

- (i) A preparatory phase which will be characterized by the conduct of pilot experiments and the development of implementation plans for the main operational phase of the program.
- (ii) The operational phase of the IGBP will begin in the early 1990's and last at least a decade. It will mark the era of coordinated study. Continuous global monitoring from both in situ and spaceborne stations can be expected during the latter part of the decade and continue into the next century.

The program will emphasize interactive processes that are not addressed by other existing programs. Topics selected for early emphasis in the IGBP include: (1) terrestrial biosphere-atmospheric chemistry interactions, (2) marine biosphere-atmospheric interactions, (3) biospheric aspects of the hydrological cycle, and (4) effects of climatic change on terrestrial ecosystems. Emphasis is also put on the need to develop an adequate global data and information system, which must be an integral part of the program.

Following the establishment of this international program, the National Academy of Sciences (NAS) organized a Committee on Global Change that will also serve as the U.S. National Committee for the IGBP. Several Federal agencies have also formulated research and observational programs related to the IGBP, e.g.:

- NSF has established a cooperative, multidisciplinary research program: the Global Geosciences Program.
- NASA's Science Advisory Council has presented a proposal for a national program to study "global change": the Earth System Science.
- NOAA has developed a proposal for a national program primarily focused on data collection and management, and climate prediction: Climate and Global Change.

Other agencies, such as DOE, EPA, and USGS are also formulating programs to contribute to the IGBP. (For further details regarding the above-mentioned national programs, and other climate-related programs, See Appendix C).

The existing National Climate Program is a key component of these broader programs of global change.

1.5 Management of the National Climate Program

The National Climate Program Act (see Appendix A) requires a cooperative effort between agencies of the U.S.

government having missions relevant to climate and climate impact response. It mandates the establishment of a National Climate Program Office (NCPO), to "serve as the lead entity responsible for administering the program". The primary responsibility of the NCPO is to ensure balance and completeness in the combined efforts of participating agencies to meet the primary goal of assisting "the Nation and the world to understand and respond to natural and man-induced climate processes and their implications." The activities of the NCP are overseen by an NCP Policy Board which has the overall responsibility for "coordinated planning and Progress review of the Program". The Board "shall establish and maintain such interagency groups as the Board determines to be necessary to carry out its activities".

The National Climate Program Act specifies several elements that the Program shall include, two of which are carried out under the direction of the National Climate Program Office. These are (1) mechanisms for intergovernmental climate-related studies and services, carried out through federal and state cooperation, and (2) augmentation of climate research activities by the establishment of experimental climate forecast centers. The NCPO has the responsibility to "protect against the premature reliance on such experimental forecasts."

In administering the program, the NCPO has the following tasks:

- Preparation and submission to the Congress, through the Secretary of Commerce, of a five-year plan at least once every four years. Each plan shall establish the goals and priorities for the Program, and contain details about

the role of the federal agencies in the programs.

- Preparation and annual submission to the President and the Congress, through the Secretary of Commerce, of an annual report showing the program activities and progress, the objectives for the forthcoming year, as well as a summary of the multiagency budget request for the Program.

In addition to its roles of coordinating and managing of intergovernmental climate-related studies and services and experimental climate forecast center activities, the NCPO is responsible, with the Department of State, for "coordinating interagency participation in international climate related activities" (relations with non-governmental international scientific organizations are handled through the National Academy of Sciences). The NCPO also facilitates information exchange through workshops and seminars between groups or agencies concerned with policy and planning for climate-sensitive activities. Toward this end, the NCPO began in 1985 a series of Strategic Planning Seminars (SPS) designed to identify emerging policy and technical issues. The first three seminars focused on drought in Africa (1985), policy aspects of climate forecasting (Krasnow, 1986), and economic and political aspects of climate change (WRI, 1988).

External scientific review of the NCP is provided by the Board on Atmospheric Science and climate of the National Research Council (NRC), and its standing Climate Research Committee in cooperation with other earth sciences activities of the NRC.

2. IMPLEMENTATION OF THE NATIONAL CLIMATE PROGRAM

This section describes the major objectives of the National Climate Program for the next five-year period, and activities required for the implementation of these objectives.

2.1 Climate Data, Analysis, and Services

The National Climate Program Act (Appendix A) states that the Program should include, but not be limited to, the following elements:

- Global data collection, and monitoring and analysis activities to provide reliable, useful, and readily available information on a continuing basis (Sec. 5.d 4);
- Systems for the management and active dissemination of climatological data, information, and assessments, including mechanisms for consultation with current and potential users (Sec. 5.d 5);

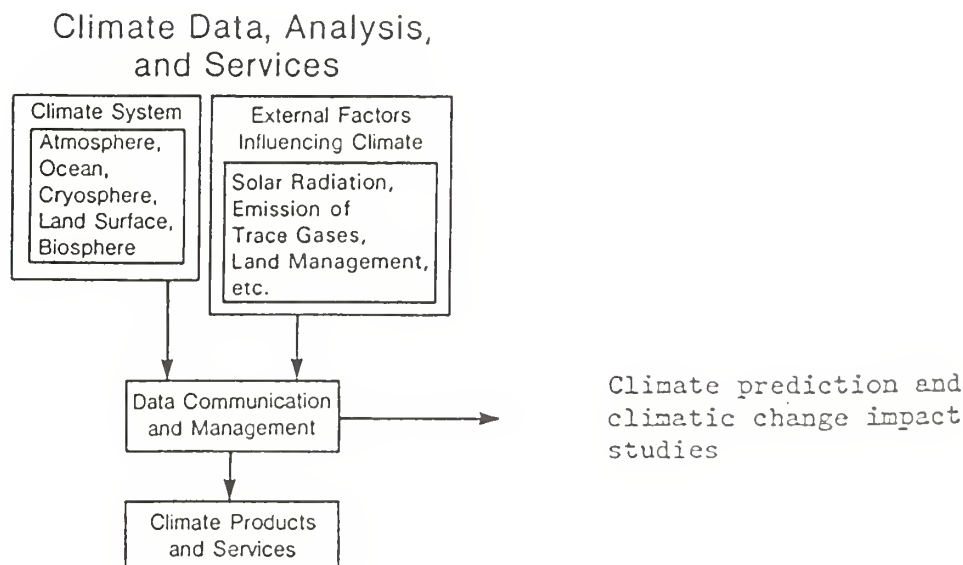
The major objectives of this component of the National Climate Program for the next five-year period are:

- To create an integrated climate information system permitting an easy access to the data specifying the climate system and the factors having an influence on climate.
- To provide climate data products and services aimed at a wide-spread utilization of climate information.

- To reconstruct past climates and to detect any changes in the current state of the climate system.

The individual pieces of the data and services section of the Five-Year Plan lay the foundation for improvements. These plans are compatible with general goals of agency-directed programs in the Global Change Program. For example, the broad goal of the NOAA Climate and Global Change Program is to improve climate prediction capabilities and to fulfill NOAA's responsibilities in a broad national and international program to understand and predict changes of the global environment. Budget increases in FY 89 have been requested by the President for this effort. Similarly, the global change related programs of NASA and NSF will contribute to building the observational base necessary to understand climatic change. NSF, through university-based research, will continue their traditional function of examining the physical, chemical, and biological processes which govern climate and determine which climate parameters should be monitored. NASA will continue development of an atmospheric chemistry and stratospheric ozone monitoring system as part of their implementation of national and international programs.

Collecting, archiving, and disseminating primary atmospheric and oceanic observations is an important public responsibility and largely rests with the federal government.



With the expected explosion in volume of primary data in the next few years, mainly from satellites and automated weather observing systems, *critical decisions will be needed in the next five years as to how climate data should be saved and in what form.*

Long-term monitoring and data access are key ingredients of future programs of global change. What is done now concerning climate monitoring and data management will likely determine how successful global change programs will be in the year 2000.

The observing system presently used for most climate purposes is primarily based on the existing weather service observing system. The end users of climate data are thus dependent on a complex network of collecting and archiving of weather data from both remote and ground-based sensors. The operational system for weather data is supplemented by an ad hoc system of federal, state, university, and private observing networks which may or may not interact with it. The combination of these networks, properly interfaced, provides an essential part to a national climate service system.

As a general rule, most users of climate information expect some processing of the data during the initial data handling phase. The most elementary level of climate services is to provide access to aggregated data for specific locations or regions, e.g., monthly mean temperatures, sunshine hours, or seasonal rainfall. However, support for even this type of service requires a complex data management system (acquisition, quality control, processing, archiving, and dissemination).

2.1.1 Monitoring the Climate System

(i) Specification of Climate Data Requirements

Determination of global changes in the environment is highly dependent on regular, complete assessments of the present state of the Earth's climate. Key questions that must be answered include: What are reliable indicators of climatic change? What are their ranges of natural variation? How can possible causes and effects be differentiated? What are the time and space scales of importance? At the present, how to monitor the global climate is still largely a research question. The goal over the next five years is to address these questions and establish a routine monitoring activity.

Recommendation:

Enhance research to examine the physical, chemical, and biological processes which govern climate, and to determine which climate parameters should be monitored for identifying a global climatic change.

(ii) Climate Observing Systems

To a large extent, instruments to measure atmospheric,

oceanographic, and other environmental parameters have been designed and used to produce real-time or near-real-time data for specific purposes, such as weather forecasting, ship routing, early warning systems, etc. These data have been used extensively to produce climate information. NASA has historically played a central role in developing new instrumentation for environmental observations and has worked cooperatively with NOAA to define instrument needs for operational satellites.

The long lead time needed to produce new satellites or new instrumentation for existing satellites requires early consideration of future data needs. National needs for environmental data in the future will almost certainly be for global data on a recurring basis from stable, calibrated instruments. The considerations must become an integral part of the present planning of the complex satellite instrument systems, such as the Earth Observing System (EOS) being proposed as part of the Space Station configuration.

Recommendations:

- Improve the monitoring of the concentration of radiatively active trace species in the atmosphere and in the oceans.
- Develop improved instrumentation for sea level measurements, by making use of e.g., the next generation water level measurement systems, portable Very Long Baseline Interferometry (VLBI) systems and Global Positioning System (GPS) units, and ancillary environmental sensors.

(iii) Climate Data Management

Data management systems and institutions that currently handle climate data include: international environmental data collection systems organized through UN agencies (WMO, IOC, UNEP, UNDP), such as the World Weather Watch (WWW), Global Environmental Monitoring System (GEMS), Global Resource Information Database (GRID), Integrated Global Ocean Station System (IGOSS), and International Ocean Data Exchange (IODE); individual national and international data management schemes specifically for research projects, such as International Satellite Cloud Climatology Project/First ISCCP Regional Experiment, International Satellite Land-Surface Climatology Project/First ISLSCP Field Experiment, and Equatorial Pacific Ocean Climate Studies/Tropical Ocean and Global Atmosphere; the NASA Pilot Climate Data System; the NSF-UCAR Unidata system, designed for service to the university community; and the National Data Centers which archive climate data and which are available for research and application purposes.

A vast amount of satellite and ground-based data are in the national archives. In order to ensure that these data, as well as the data being collected today will be available in the future, dedicated efforts must be made; e.g., there is a

need to identify what archived data are usable, what information should continue to be saved, and how. Furthermore, it will be necessary to improve the entire process of data handling and storage.

Stability and continuity of data sets are two critical requirements for climate purposes. Changes in instrumentation or operational procedures must be made in ways to ensure, as far as possible, the compatibility of data sets. This is especially true with regard to satellite data. Care must be exercised in setting up and operating data networks to provide reasonable longevity and homogeneity of the data.

At the same time, methods must be incorporated into initial data processing activities which will extract as much primary and secondary (i.e., integrated) climate data as practical before the data are archived. This is particularly critical in cases where the data volume is large, making reprocessing prohibitive, or in cases where the initial data are never saved.

Satellite data will be more extensively used to provide long-term data records for climatic studies. An informative and available history of the performance and stability of each satellite instrument must be developed.

At least two other national data management systems based on direct telecommunications between the user and the data archives exist: the NASA Pilot Climate Data System and the NSF-UCAR Unidata System. Coordination of all data management systems, including those created for national and international research activities, is needed to improve national access to climate data.

Recommendations:

- In close collaboration with the World Climate Data Programme, improve access to data representing the individual components of the climate system and the factors having an influence on climate.
- Develop improved methods for extracting information on climate parameters from operational satellite sensors, and programs for calibrating and validation in order to ensure consistency in long-term research data sets.
- Recompute the analyses of the data obtained during the First GARP Global Experiment (FGGE) 1978-79.

2.1.2 Climate Data and Products and Services

Climate products, such as the material contained in the Weekly Climate Bulletin (NOAA), the Climate Diagnostics Bulletin (NOAA), the Oceanographic Monthly Summary (NOAA), and the Weekly Weather and Crop Bulletin (NOAA/USDA) provide climate information for government and industry users. These products are derived from the extensive data information systems and research that form the foundation of the National Climate Program.

Weekly crop condition assessments are provided on a global basis and monthly crop yields are also done by the Joint Agricultural Weather Facility (JAWF) of USDA and NOAA for use by USDA economic agencies in preparation of the world agriculture supply and demand estimates (WASDE). These assessments are then used by both government and the private sector.

NOAA also prepares monthly and seasonal (90-day) climate outlooks and collects and analyzes data to depict current climate anomalies (Figure 10).

The federal government's role in collecting, archiving, and disseminating climate data is inevitable in light of the increasing reliance on satellite systems as primary data sources, and the interdependence of national and foreign data sources. It is also true that regional interests (between states) create different needs for climate information and analyses. Private meteorological services will be encouraged to develop products to meet the growing public need for climate information. This will require, though, that data sources be easily available.

In many cases, the general public and special users are not aware of what climate data, information, assessments, and predictions are available. A key service to the nation is to ensure that those who have use for climate products are made aware of what is being produced. Greater use of the climate products tends, at the same time, to improve them. Making potential users aware of available climate information is also needed within the federal government. This is especially true in many planning activities where climate issues are important, but often are not considered.

Recommendation:

- Encourage the private sector to develop climate products, and to increase the level of awareness of the availability of climate information and products.

2.1.3 Climatic Change and Variability

(i) Reconstruction of Past Climates and Analysis of their Causes

Historical and paleoclimate data derived from ice cores, varved lakes, and deep sea sediments provide a significant source of information on past climatic changes. Analyses of these data provide essential information for validation of climate models under radically different boundary conditions and provide a valuable reference against which to gauge future climate change and distinguish natural from man-made changes.

Analyses of marine sediment cores have demonstrated the importance of the Earth's orbital cycles in determining climate and climatic change. Continuing efforts are needed to understand the nature of the climate response to orbital forc-

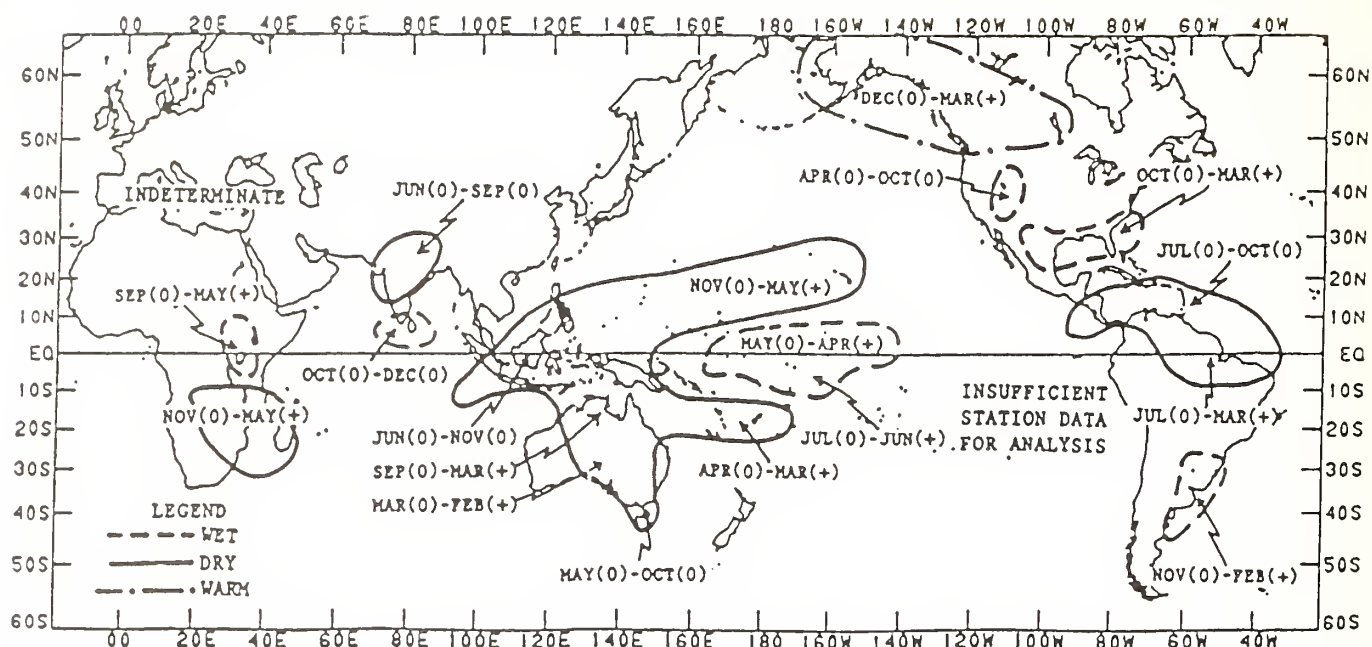


Figure 10. Regions which have been identified as likely to experience significant climatic responses to an El Niño - Southern Oscillation (ENSO) event. A "O" in parenthesis after the month indicates the month of the same year as the ENSO event began, and a "+" indicates the following year (Ropelewski and Halpert, 1987).

ing both in terms of its spatial and temporal variability and the physical processes involved.

Following the success of the Greenland Ice Sheet Program (GISP), a collaborative drilling effort of the U.S., Denmark, and Switzerland, ice cores in mountain glaciers and Antarctica have yielded considerable insight into the rate and magnitude of climate change over the past 10,000 years. A new program for renewed drilling in Greenland is now under development.

Recent published USGS studies of temperature changes in permafrost regions suggest a 2-4 degree Celsius warming over the past 100 years. A network exists for measuring temperatures in the permafrost. The NCPO, NSF's Arctic Research Systems Studies Program, and the USGS will develop a program to monitor permafrost as an integrated measure of climate change.

A comparison of general circulation model simulations with geologic data during regular intervals over the past 18,000 years shows good agreement in midlatitude regions. This research has led to improved understanding of climate variability on the millennial time scale. Continued model and data studies are needed in the next five years to resolve differences in other regions.

Recommendations:

- Enhance studies of the causes of fluctuations in past climate, examining criteria for detecting long-term climatic

change, and investigating evidence for and causes of rapid climatic change.

- Enhance studies of climate and environmental changes in ice cores from Greenland and Antarctica.
- Evaluate past climate periods as possible analogues for future climates caused by greenhouse warming.

(ii) Changes in the Composition of the Atmosphere and Present Climate Trends

The basic goal of this program element is to provide a realistic assessment of the present and expected future emission and concentrations of the main radiatively active gases, and to evaluate how they are modifying the radiation balance of the Earth's atmosphere thereby influencing the global climate. At present, the yearly rate of increase of the most significant trace gases are: carbon dioxide (CO₂), 0.3%; the two most important chlorofluorocarbons (CFCl₃-F11 and CF₂Cl₂-F12), 5-7%; methane (CH₄), 1.1-1.3%; and nitrous oxide (NO₂), 0.3%. Due to their radiative properties, transparent to the incoming short-wave (solar) radiation but absorbing the long-wave (infrared) radiation emitted by the Earth's surface, they all contribute to a warming of the lower atmosphere (troposphere). It is this trapping of the radiation which is referred to as the greenhouse effect, and it is why these gases are called greenhouse gases.

Ozone (O₃) has somewhat different properties than the other greenhouse gases. In addition to absorbing and emitting longwave radiation, it also absorbs short-wave radiation. Consequently, a reduction of the stratospheric ozone

impacts of climatic variability and change. As these and other studies progress, more knowledge will accumulate on just how to integrate socio-economic and ecological system changes for future assessments. The national climate programs of the U.S. and Canada are organizing a conference on the impact of climatic change in the Great Lakes Basin as a start of a comprehensive program of integrated regional impact studies.

Recommendation:

- Undertake studies aimed at obtaining comprehensive regional assessments for climatologically sensitive regions, integrating short-term and long-term socio-economical and ecological adjustments.

2.3.3 Response Strategies

According to the Global Climate Protection Act of 1987, the goals of the U.S. policy should seek to:

- (i) Increase worldwide understanding of the greenhouse effect and its environmental and health consequences.

- (ii) Foster cooperation among nations to develop more extensive and coordinated scientific research efforts on the greenhouse effect.
- (iii) Identify technologies and activities to limit mankind's adverse effect on the global climate by:
 - slowing the rate of increase of concentrations of greenhouse gases in the atmosphere in the near term.
 - stabilizing or reducing atmospheric concentrations of greenhouse gases over the long term.
- (iv) Work toward multilateral agreements.

Recommendations:

- Develop a coordinated national policy on global climatic change in accordance with the mandate for action stated in the Global Climate Protection Act.
- Prepare a response to a Congressional request (see Appendix D) for reports on (a) health and environmental effects of climate change and (b) policy options for stabilizing current levels of atmospheric greenhouse gas emissions.
- Continue ongoing policy studies related to energy efficiency and alternative energy sources.

3. NATIONAL CLIMATE PROGRAM BUDGET

The NCP Act requires the Office of Management and Budget to review all federal agency requests for funding of climate activities as an integrated, coherent, multiagency budget. Accordingly, the NCPO compiles budget data from the federal agencies and prepares an analysis for OMB. Federal funding, by agency, for the NCP for 1987-1989 is shown in Table 2.

Support for NCP activities is extensive across the federal agencies. In any single agency, climate-related activities may exist in several programs. The distinction between programs in and out of the NCP is often blurred. For example, NASA's sizable effort directed toward studies of ozone depletion is not included, whereas NOAA's broad efforts to monitor greenhouse gases, including CFCs, is included. The summary tables do not include the extensive support for satellite systems even though they are essential for climate observations.

Accounting for the NCP, therefore, involves some subjectivity. The determination of agency funding for the NCP is made by individual agencies. The NCPO compiles the figures and develops an integrated analysis. The accompanying narrative defines the broad areas of agency support in the NCP, and program increases specified in the President's 1989 budget to Congress.

Beginning in the 1987 budget, several federal agencies introduced the concept of global change, which is broadly defined as programs which contribute to an integrated understanding of the Earth's processes. A common definition of Global Change acceptable to all federal agencies is not yet available, although the Committee on Earth Sciences (CES) is actively engaged in formulating such a definition. For the purpose of this plan, Global Change is defined as a conceptual model involving many geoscience programs, of which the NCP is one major component. Other programs included in global change, but not included in the NCP, are Global Tropospheric Chemistry, Ocean Flux, and Global Ecosystem Dynamics programs.

TABLE 2
National Climate Program Budget, By Agency
FY 1987, FY 1988, FY 1989
(in million \$)

FEDERAL AGENCIES	FY1987	FY1988	FY1989
Agriculture ¹	28.3	28.9	31.9
Commerce ²	53.4	50.7	59.5
Defense ³	13.0	14.3	11.2
Energy ⁴	13.9	14.7	18.5
EPA ⁵			
Global Warming	4.2	5.0	5.7
Stratospheric Ozone	4.8	4.8	12.0
Subtotal	9.0	9.8	17.7
Interior ⁶	1.0	1.0	1.0
NASA			
Research	6.1	6.3	6.6
Climate Obs.	10.6	9.3	11.6
Data Management	0.7	0.7	0.7
Subtotal	17.4	16.3	18.9
NSF ⁷	55.4	56.5	66.1
NCPO ⁸	2.7	2.4	3.0
TOTAL	194.1	194.1	227.8

¹Includes World Outlook Board and research on climate effects on agricultural food and fiber. Assessment of CO₂ effects on agriculture is done with additional resources provided by DOE.

²DOC/NOAA program includes support for observational and data management system, e.g., GMCC stations around the world, NCDC and other data centers, and observational systems needed to support research programs such as TOGA, climate research and modeling at ERL laboratories, particularly GFDL, and climate prediction by NWS and OAR.

Increases in FY 89 of \$9 M for climate and global change includes \$4.0 M for data analysis and management, \$3.0 M for global sea level, \$4.0 M for an ocean observing network, and \$1.0 M for ozone monitoring.

³The figures primarily reflect the budget of the DOD Environmental Technical Applications Center (ETAC) of about \$11 M; year-to-year variations are principally driven by equipment purchases to upgrade capabilities of ETAC and its unit at Asheville, N.C.

⁴Increase in FY 89 funding includes \$1.0 M for policy studies.

⁵FY88 \$3.0 M supports workshops, and analysis for two reports requested by Congress on climate effects and policy options. Remaining funds are used for basic research in emissions and effects.

⁶DOI climate activities are concentrated in the USGS and include paleoclimate reconstructions, global geochemical cycles and hydrology.

⁷The budgets include funding for NCP activities and support of WCRP observational programs (TOGA, WOCE, ISCCP, ISLSCP), the Global Tropospheric Chemistry, the Ocean Flux and Global Ecosystems, and the Paleoclimate programs.

⁸FY 88 and FY 89 budgets reflect congressional add-on of \$1.2 M and \$1.5 M to support regional climate centers. Not requested by Commerce in the FY 89 budget because funding responsibility for state and regional programs should be funded by the direct beneficiaries. Basic NCPO supports coordination activities and research for experimental forecasting research.

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APPENDIX A

THE NATIONAL CLIMATE PROGRAM ACT

as enacted by Public Law 95-367 (Sept. 17, 1978) and amended by Public Law 97-375 (Dec. 21, 1982), and Public Law 99-272 (Apr. 7, 1986); 15 U.S.C. 2901 et seq.

An Act

To establish a comprehensive and coordinated national climate policy and program, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "National Climate Program Act".

SEC. 2. FINDINGS.

The Congress finds and declares the following:

- (1) Weather and climate change affect food production, energy use, water resources and other factors vital to national security and human welfare.
- (2) An ability to anticipate natural and man-induced changes in climate would contribute to the soundness of policy decisions in the public and private sectors.
- (3) Significant improvements in the ability to forecast climate on an intermediate and long-term basis are possible.
- (4) Information regarding climate is not being fully disseminated or used, and Federal efforts have given insufficient attention to assessing and applying this information.
- (5) Climate fluctuation and change occur on a global basis, and deficiencies exist in the system for monitoring global climate changes. International cooperation for the purpose of sharing the benefits and costs of a global effort to understand climate is essential.
- (6) The United States lacks a well-defined and coordinated program in climate-related research, monitoring, assessment of effects, and information utilization.

SEC. 3. PURPOSE.

It is the purpose of the Congress in this Act to establish

a national climate program that will assist the Nation and the world to understand and respond to natural and man-induced climate processes and their implications.

SEC. 4. DEFINITIONS.

As used in this Act, unless the context otherwise requires:

- (1) The term "Board" means the Climate Program Policy Board.
- (2) The term "Office" means the National Climate Program Office.
- (3) The term "Program" means the National Climate Program.
- (4) The term "Secretary" means the Secretary of Commerce.

SEC. 5. NATIONAL CLIMATE PROGRAM.

- (a) **Establishment.**—The President shall establish a National Climate Program in accordance with the provisions, findings and purposes of this Act.
- (b) **Duties.**—The President shall—
 - (1) promulgate the 5-year plans described in subsection (d)(9);
 - (2) define the roles in the Program of Federal officers, departments, and agencies, including the Departments of Agriculture, Commerce, Defense, Energy, Interior, State, and Transportation; the Environmental Protection Agency; the National Aeronautics and Space Administration; the Council on Environmental Quality; the National Science Foundation; and the Office of Science and Technology Policy; and
 - (3) provide for Program coordination.
- (c) **National Climate Program Office.**
 - (1) The Secretary shall establish within the Department of Commerce a National Climate Program Office not later than 30 days after the date of the enactment of this Act (enacted Sept. 17, 1978).
 - (2) The Office shall—
 - (A) serve as the lead entity responsible for administering the program;
 - (B) be headed by a Director who shall represent the Climate Program Policy Board and shall be spokesperson for the program;
 - (C) serve as the staff for the Board and its supporting committees and working groups;

- (D) review each agency budget request transmitted under subsection (g)(1) and submit an analysis of the requests to the Board for its review;
- (E) be responsible for coordinating interagency participation in international climate-related activities; and
- (F) work with the National Academy of Sciences and other private, academic, State, and local groups in preparing and implementing the 5-year plan (described in subsection (d)(9) and the Program.

The analysis described in subparagraph (D) shall include an analysis of how each agency's budget request relates to the priorities and goals of the program established pursuant to this Act.

- (3) The Secretary may provide, through the Office, financial assistance, in the form of contracts or grants or cooperative agreements, for climate-related activities which are needed to meet the goals and priorities of the program set forth in the 5-year plan pursuant to subsection (d)(10)), if such goals and priorities are not being adequately addressed by any Federal department, agency, or instrumentality.
- (4) Each Federal officer, employee, department and agency involved in the Program shall cooperate with the Secretary in carrying out the provisions of this Act.

(d) Program Elements.—The Program shall include, but not be limited to, the following elements:

- (1) assessments of the effect of climate on the natural environment, agricultural production, energy supply and demand, land and water resources, transportation, human health and national security. Such assessments shall be conducted to the maximum extent possible by those Federal agencies having national programs in food, fiber, raw materials, energy, transportation, land and water management, and other such responsibilities, in accordance with existing laws and regulations. Where appropriate such assessments may include recommendations for action;
- (2) basic and applied research to improve the understanding of climate processes, natural and man-induced, and the social, economic, and political implications of climate change;
- (3) methods for improving climate forecasts on a monthly, seasonal, yearly, and longer basis;
- (4) global data collection, and monitoring and analysis activities to provide reliable, useful and readily available information on a continuing basis;
- (5) systems for the management and active dissemination of climatological data, information and assessments, including mechanisms for consultation with current and potential users;

- (6) measures for increasing international cooperation in climate research, monitoring, analysis and data dissemination;

- (7) mechanisms for intergovernmental climate-related studies and services including participation by universities, the private sector and others concerned with applied research and advisory services. Such mechanisms may provide, among others, for the following State and regional services and functions:

- (A) studies relating to and analyses of climatic effects on agricultural production, water resources, energy needs, and other critical sectors of the economy;
- (B) atmospheric data collection and monitoring on a statewide and regional basis;
- (C) advice to regional, State, and local government agencies regarding climate-related issues;
- (D) information to users within the State regarding climate and climatic effects; and
- (E) information to the Secretary regarding the needs of persons within the States for climate-related services, information, and data.

The Secretary may make annual grants to any State or group of States, which grants shall be made available to public or private educational institutions, to State agencies, and to other persons or institutions qualified to conduct climate-related studies or provide climate-related services;

- (8) experimental climate forecast centers, which shall—
 - (A) be responsible for making and routinely updating experimental climate forecasts of a monthly, seasonal, annual, and longer nature, based on a variety of experimental techniques;
 - (B) establish procedures to have forecasts reviewed and their accuracy evaluated; and
 - (C) protect against premature reliance on such experimental forecasts; and
- (9) a preliminary 5-year plan, to be submitted to the Congress for review and comment, not later than 180 days after the enactment of this Act (enacted Sept. 17, 1978), and a final 5-year plan to be submitted to the Congress not later than 1 year after the enactment of this Act (enacted Sept. 17, 1978), that shall be revised and extended at least once every four years. Each plan shall establish the goals and priorities for the Program, including the intergovernmental program described in paragraph

- (7), over the subsequent 5-year period, and shall contain details regarding
 - (A) the role of Federal agencies in the programs,
 - (B) Federal funding required to enable the Program to achieve such goals, and
 - (C) Program accomplishments that must be achieved to ensure that Program goals are met within the time frame established by the plan.

(e) Climate Program Policy Board.

- (1) The Secretary shall establish and maintain an inter-agency Climate Program Policy Board, consisting of representatives of the Federal agencies specified in subsection (b)(2) and any other agency which the Secretary determines should participate in the Program.
- (2) The Board shall—
 - (A) be responsible for coordinated planning and progress review for the Program;
 - (B) review all agency and department budget requests related to climate transmitted under subsection (g) and submit a report to the Office of Management and Budget concerning such budget requests;
 - (C) establish and maintain such interagency groups as the Board determines to be necessary to carry out its activities; and
 - (D) consult with and seek the advice of users and producers of climate data, information, and services to guide the Board's efforts, keeping the Director and the Congress advised of such contacts.
- (3) The Board biennially shall select a Chair from among its members. A Board member who is a representative of an agency may not serve as Chair of the Board for a term if an individual who represented that same agency on the Board served as the Board's Chair for the previous term.

(f) Cooperation.

- (1) The Program shall be conducted so as to encourage cooperation with, and participation in the Program by, other organizations or agencies involved in related activities. For this purpose the Secretary shall cooperate and participate with other Federal agencies, and foreign, international, and domestic organizations and agencies involved in international or domestic climate-related programs.
- (2) The Secretary and the Secretary of State shall cooperate with the Office in
 - (A) providing representation at climate-related international meetings and conferences in which the United States participates, and

- (B) coordinating the activities of the Program with the climate programs of other nations and international agencies and organizations; including the World Meteorological Organization, the International Council of Scientific Unions, the United Nations Environmental Program, the United Nations Educational, Scientific, and Cultural Organization, the World Health Organization, and Food and Agriculture Organization.

(g) Budgeting.

- (1) Each Federal agency and department participating in the Program, shall prepare and submit to the Office of Management and Budget, on or before the date of submission of departmental requests for appropriations to the Office of Management and Budget, an annual request for appropriations for the Program for the subsequent fiscal year and shall transmit a copy of such request to the National Climate Program Office. The Office of Management and Budget shall review the request for appropriations as an integrated, coherent, multi-agency request.
- (2) Section 304 of the Act of October 18, 1962 (31 U.S.C. 25) (relating to preparation of horizontal budgets for meteorology), is amended—
 - (A) by inserting “and of the National Climate Program established under the National Climate Program Act” after “meteorology”, and
 - (B) by striking out “aspects of the program” and inserting in lieu thereof “aspects of the programs”.

The amendments made by the preceding sentence shall apply with respect to budgets submitted for fiscal years beginning 6 months or more after the date of the enactment of this Act.

SEC. 6. REPEALED

SEC. 7. ANNUAL REPORT.

The Secretary shall prepare and submit to the President and the authorizing committees of the Congress, not later than March 31 of each year, a report on the activities conducted pursuant to this Act during the preceding fiscal year, including—

- (a) a summary of the achievements of the Program during the previous fiscal year;
- (b) an analysis of the progress made toward achieving the goals and objectives of the Program;
- (c) a copy of the 5-year plan and any changes made in such plan;
- (d) a summary of the multiagency budget request for the Program of subsection 5(g)(1); and

(e) any recommendations for additional legislation which may be required to assist in achieving the purposes of the Act.

**SEC. 8. CONTRACT AND GRANT AUTHORITY;
RECORDS AND AUDITS.**

- (a) Functions vested in any Federal officer or agency by this Act or under the Program may be exercised through the facilities and personnel of the agency involved or, to the extent provided or approved in advance in appropriation Acts, by other persons or entities under contracts or grant arrangements entered into by such officer or agency.
- (b) (1) Each person or entity to which Federal funds are made available under a contract or grant arrangement as authorized by this Act shall keep such records as the Director of the Office shall prescribe, including records which fully disclose

the amount and disposition by such person or entity of such funds, the total cost of the activities for which such funds were so made available, the amount of that portion of such cost supplied from other sources, and such other records as will facilitate an effective audit.

- (2) The Director of the Office and the Comptroller General of the United States, or any of their duly authorized representatives, shall, until the expiration of 3 years after the completion of the activities (referred to in paragraph (1)) of any person or entity pursuant to any contract or grant arrangement referred to in subsection (a), have access for the purpose of audit and examination to any books, documents, papers, and records of such person or entity which, in the judgment of the Director or the Comptroller General, may be related or pertinent to such contract or grant arrangement.

APPENDIX B

THE GLOBAL CLIMATE PROTECTION ACT

as enacted by Public Law 100-204 (December 22, 1987).

SEC. 1101 SHORT TITLE

This title may be cited as the “Global Climate Protection Act of 1987”.

SEC. 1102 FINDINGS

The Congress finds as follows:

- (1) There exists evidence that man made pollution—the release of carbon dioxide, chlorofluorocarbons, methane, and other trace gases into the atmosphere—may be producing a long term and substantial increase in the average temperature on Earth, a phenomenon known as global warming through the greenhouse effect.
- (2) By early in the next century, an increase in Earth temperature could—
 - (A) so alter global weather patterns as to have an effect on existing agricultural production and on the habitability of large portions of the Earth; and
 - (B) cause thermal expansion of the oceans and partial melting of the polar ice caps and glaciers, resulting in rising sea levels.
- (3) Important research into the problem of climate change is now being conducted by various United States Government and international agencies, and the continuation and intensification of those efforts will be crucial to the development of an effective United States response.
- (4) While the consequences of the greenhouse effect may not be fully manifest until the next century, ongoing pollution and deforestation may be contributing now to an irreversible process. Necessary actions must be identified and implemented in time to protect the climate.
- (5) The global nature of this problem will require vigorous efforts to achieve international cooperation aimed at minimizing and responding to adverse climate change; such international cooperation will be greatly enhanced by United States leadership. A key step in international

cooperation will be the meeting of the Governing Council of the United Nations Environment Program, scheduled for June 1989, which will seek to determine a direction for worldwide efforts to control global climate change.

- (6) Effective United States leadership in the international arena will depend upon a coordinated national policy.

SEC. 1103 MANDATE FOR ACTION ON THE GLOBAL CLIMATE

- (a) **Goals of United States Policy**—United States policy should seek to—

- (1) increase worldwide understanding of the greenhouse effect and its environmental and health consequences;
- (2) foster cooperation among nations to develop more extensive and coordinated scientific research efforts with respect to the greenhouse effect;
- (3) identify technologies and activities to limit mankind's adverse effect on the global climate by
 - (A) slowing the rate of increase of concentrations of greenhouse gases in the atmosphere in the near term; and
 - (B) stabilizing or reducing atmospheric concentrations of greenhouse gases over the long term; and
- (4) work toward multilateral agreements.

- (b) **Formulation of United States Policy**

The President, through the Environmental Protection Agency, shall be responsible for developing and proposing to Congress a coordinated national policy on global climate change. Such policy formulation shall consider research findings of the Committee on Earth Sciences of the Federal Coordinating Council on Science and Engineering Technology, the National Academy of Sciences, the National Oceanic and Space Administration, the Department of Energy, the Environmental Protection Agency, and other organizations engaged in the conduct of scientific research.

- (c) **Coordination of United States Policy in the International Arena**

The Secretary of State shall be responsible to coordinate those aspects of United States policy requiring

action through the channels of multilateral diplomacy, including the United Nations Environment Program and other international organizations. In the formulation of these elements of United States policy, the Secretary of State shall, under the direction of the president, work jointly with the Administrator of the Environmental Protection Agency and other United States agencies concerned with environmental protection, consistent with applicable Federal law.

SEC. 1104 REPORT TO CONGRESS

Not later than 24 months after the date of enactment of this Act, the Secretary of State and the Administrator of the Environmental Protection Agency shall jointly submit to all committees of jurisdiction in the Congress a report which shall include—

- (1) a summary analysis of current international scientific understanding of the greenhouse effect, including its environmental and health consequences;
- (2) an assessment of United States efforts to gain international cooperation in limiting global climate change; and

- (3) a description of the strategy by which the United States intends to seek further international cooperation to limit global climate change.

SEC. 1105 INTERNATIONAL YEAR OF GLOBAL CLIMATE PROTECTION

In order to focus international attention and concern on the problem of global warming and to foster further work on multilateral treaties aimed at protecting the global climate, the Secretary of State shall undertake all necessary steps to promote, within the United Nations system, the early designation of an International Year of Global Climate Protection.

SEC. 1106 CLIMATE PROTECTION AND UNITED STATES—SOVIET RELATIONS

In recognition of the respective leadership roles of the United States and the Soviet Union in the international arena, and of their joint role as the world's two major producers of atmospheric pollutants, the Congress urges that the President accord the problem of climate protection a high priority on the agenda of United States-Soviet relations.

APPENDIX C

SCIENTIFIC PROGRAMS AND ACTIVITIES RELATED TO THE NATIONAL CLIMATE PROGRAM

1. Programs of Federal Agencies related to the International Geosphere Biosphere Programme (IGBP)

1.1 NSF: The Global Geosciences Program

The National Science Foundation has initiated (1986) a cooperative, multidisciplinary research program called *Global Geosciences*. The program includes studies of global oceanic and atmospheric circulation, global tropospheric chemistry, exchanges of biological and chemical materials within the oceans and between the atmosphere, the earth and the oceans, as well as properties of the solid Earth.

The central goal of Global Geosciences is to understand how the Earth functions as a system of interrelated processes, and to establish major cause-and-effect relationships within and between the climate system, biogeochemical cycles and tectonic activity, all operating within the atmosphere, oceans, biosphere and solid Earth.

Component programs of Global Geosciences, with particular emphasis on environmental chemistry and biochemistry, include global tropospheric chemistry, global ocean flux and global ecosystem dynamics, wherein sources and sinks of natural and anthropogenic materials are studied to understand the processes controlling the Earth's environment.

1.2 NASA: Earth System Science

Also in 1986, NASA's Science Advisory Council completed a report which presents a proposal for a national program to study global change: the Earth System Science. It is a holistic approach to the study of the Earth's stresses investigation of the interactions among the Earth components in order to explain the dynamics of the Earth's evolution and change.

The goal of the Earth System Science is to obtain a scientific understanding of the entire Earth system by describing how its component parts and their interactions have evolved, how they function, and how they may be expected to continue to evolve on all time scales.

Two program paths are recommended for the next ten years:

- (i) Measurements of fundamental solid Earth characteris-

tics for an understanding of planetary evolution on longer time scales.

- (ii) Studies of the fluid and biological Earth for an understanding of global change over the next decade to century.

1.3 NOAA: Climate and Global Change

The FY 1989 President's budget requests funding to establish an integrated program in Climate and Global Change to improve NOAA's climate prediction capabilities, and fulfill NOAA's responsibilities in a broad national and international program to understand and predict changes in the global environment. NOAA's program will emphasize data analysis plus ocean and ozone monitoring systems.

1.4 FCCSET: Committee on Earth Sciences

In 1987 the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) established a *Committee on Earth Sciences* (CES) with representatives from twelve departments and agencies (Department of Agriculture, Commerce, Defense, Energy, Interior, State; NSF, EPA, NASA, OSTP, OMB, and CEQ) in order to increase the overall effectiveness and productivity of federal R&D efforts directed toward an understanding of the Earth as a global system.

2. Arctic Research and Policy Act (PL 98-373)

The Arctic Research and Policy Act (ARPA) of 1984 established the Interagency Arctic Research Policy Committee to prepare a plan for federal activities in the Arctic. Unlike the National Climate Program Act which focuses on a specific problem, ARPA covers many different problems (only one of which is climate) for a specific region of the world; albeit one with strategic, social, and economic importance.

The National Climate Program Office, NOAA, and the Interagency Arctic Research Policy office, NSF, are working together to prepare the weather and climate portions of the Arctic plan. An understanding of the role of the Arctic in global climatic change, the dynamic and radiative balance

of Arctic sea ice, the long-term stability of the permafrost, sources and sinks of trace gases, and the potential impact of climatic change is essential for both programs. The basic approach to these key questions is a program of improved observations, modeling, and climate impact studies.

3. The Global Tropospheric Chemistry Program

The Global Tropospheric Chemistry Program (GTCP) is a U.S.-coordinated research effort to understand the processes that control the composition of the troposphere. Its objectives are:

- To understand the basic chemical cycles in the troposphere through field investigations, numerical modeling, and laboratory studies.
- To predict tropospheric responses and consequences of natural and man-induced perturbations to these atmospheric chemical cycles.
- To provide the information required for effective future understanding of the atmospheric component of the global life support system.

4. National Acid Precipitation Assessment Program

The National Acid Precipitation Assessment Program was established in late 1980 for a period of ten years. The national program involves 12 agencies, headed by USDA, NOAA, and EPA. The National Program addresses urgent demands for information while maintaining the essential objectivity that is central to its scientifically oriented, policy-neutral mandate. While the National Climate Program and the National Acid Rain Program have not in the past had significant interaction, the increased emphasis to be placed on climate impact assessment over the next five years will necessitate stronger coordination.

5. Coordinating Committee on the Ozone Layer

The Coordinating Committee on the Ozone Layer (CCOL) was formed by UNEP in 1977 and consists of international, governmental, and nongovernmental representatives from groups having active ozone layer research programs. Based on national research results, this committee makes and publishes assessments of ozone layer modification and its impact. An ad hoc working group of the CCOL was convened in 1982, and is now considering the need for, and the form of, a protocol on chlorofluorocarbon (CFC) production.

6. Interagency Committee for Stratospheric Ozone Protection.

In view of the increasing threat to the ozone layer caused by the growing use of chlorofluorocarbons (CFCs), the Environmental Protection Agency decided in 1986, following its mandate under the Clean Air Act, to enhance its efforts related to the protection of the stratospheric ozone concentration. Specific actions include:

- Increased research and analysis of issues related to future emissions of CFCs and other ozone-modifying substances, their effects on the ozone layer and climate changes, and the potential health and environmental impacts of such changes.
- Active participation in negotiations being conducted by the United Nations Environment Program aimed at achieving a global response to protecting the ozone layer.

To help coordination of the activities of federal agencies in this regard, and to provide scientific support needed to develop sound regulatory decisions, it was decided to reestablish the Interagency Committee for the Stratospheric Ozone Protection (ICSOP).

APPENDIX D

ROBERT T. STAFFORD, VERMONT, CHAIRMAN

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United States Senate

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

WASHINGTON, DC 20510

September 12, 1986

Mr. Lee Thomas
Administrator
Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Thomas:

The purpose of this letter is to formally request that EPA undertake two studies on climate change due to the greenhouse effect and submit them to Congress no later than March 31, 1988.

At the outset, we want to thank you for appearing before the Subcommittee on Environmental Pollution at hearings last June on the problems of global climate change and stratospheric ozone depletion. Your testimony showed a refreshing appreciation for the magnitude of the environmental risks presented by these problems and the need to be exploring incremental actions that can be taken to reduce these risks.

As summarized at those hearings and elsewhere, the scientific community appears to have reached agreement that substantial ozone depletion may result from continued use of chlorofluorocarbons (CFC's) and that increases in CFC's and other greenhouse gases are like to produce global climate changes greater than any in man's history. There is a very real possibility that man - through ignorance or indifference, or both - is irreversibly altering the ability of our atmosphere to perform basic life support functions.

What is urgently needed now is for us to begin to deal with these issues. They can no longer be treated solely as important scientific questions. First, some actions including limits on CFC's appear warranted in the near term. Second, we need to expand efforts to more fully understand the effects that atmospheric pollution has on the environment and to develop an extensive range of policy options for dealing with the serious global problem of climate change due to the greenhouse effect. This second need has led to our request for two EPA studies.

One of the studies we are requesting should examine the health and environmental effects of climate change. This study should include, but not be limited to, the potential impacts on agriculture, forests, wetlands, human health, rivers, lakes and estuaries as well as other ecosystems and societal impacts. This

Mr. Lee Thomas
September 9, 1986
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study should be designed to include original analyses to identify and fill in where important research gaps exist, and to solicit the opinions of knowledgeable people throughout the country through a process of public hearings and meetings.

The other study should include an examination of the policy options that, if implemented, would stabilize current levels of atmospheric greenhouse gas emissions. This study should address: the need for and implications of significant changes in energy policy, including energy efficiency and development of alternatives to fossil fuel; reductions in the use of CFC's; ways to reduce other greenhouse gases such as methane and nitrous oxides; as well as the potential for and effects of reducing deforestation and increasing reforestation efforts. It should include a series of policy options and recommendations for concrete steps to be taken along with a discussion of the potential effectiveness of each for limiting climate change. Since the United States must take a leadership role in addressing these global problems, the policy options that you develop should include a specific plan for what the United States can do to stabilize its share of greenhouse gas emissions as well as a plan for helping other nations to achieve comparable levels of control.

We realize that undertaking this project will be a significant challenge and will require substantial resources. We therefore urge you to immediately direct the necessary funds in both FY-87 and FY-88 to assure that you can comply with our request to promptly conduct these studies.

Many of us believe that these are among the most important environmental problems of the next decade. The sooner you can provide recommendations to Congress, the sooner we will be able to provide leadership throughout the world to prevent a pending environmental disaster.

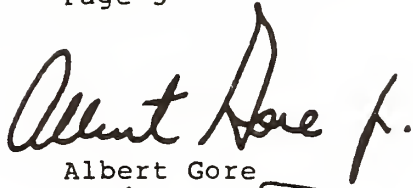
Your personal attention and prompt reply to this request will be greatly appreciated. We look forward to working with you on these important environmental problems. Please do not hesitate to contact us for additional guidance and assistance.

Sincerely,


George J. Mitchell


John H. Chafee

Mr. Lee Thomas
September 9, 1986
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Albert Gore


Max Baucus


Patrick J. Leahy


Robert T. Stafford


Dave Durenberger


Gordon J. Humphrey

APPENDIX E

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APPENDIX F

ACRONYMS

AAAS	American Association for the Advancement of Science
AGNET	Agriculture Management Network
ARPA	Arctic Research and Policy Act
AWDN	Automated Weather Data Network
BASC	Board on Atmospheric Sciences and Climate (NAS)
CAC	Climate Analysis Center (NOAA)
CCCO	Committee on Climate Change and the Ocean (IOC/SCOR)
CCOL	Coordinating Committee on the Ozone Layer (UNEP)
CES	Committee on Earth Sciences (FCCSET)
CEQ	Council on Environmental Quality
CFC	Chlorofluorocarbon
CH ₄	Methane
CLICOM	Climate Computer System (WCDP)
CO ₂	Carbon Dioxide
DMSP	Defense Meteorological Satellite Program
DOE	Department of Energy
DOS	Department of State
DOT	Department of Transportation
ECMWF	European Center for Medium Range Weather Forecasts
ENSO	El Nino—Southern Oscillation
EOS	Earth Observing System
EPA	Environmental Protection Agency
ERB	Earth Radiation Budget Mission
ERBE	Earth Radiation Budget Experiment (NASA)
ERS	Earth Resources Satellite
ESA	European Space Agency
ETAC	Environmental Tactical Analysis Center (Air Force Air Weather Service)
FCCSET	Federal Coordinating Council for Science, Engineering, and Technology
FGGE	First GARP Global Experiment (WMO/ICSU)
FY	Fiscal Year
GARP	Global Atmospheric Research Program
GEMS	Global Environmental Monitoring System (UNEP)
GFDL	Geophysical Fluid Dynamics Laboratory
GISP	Greenland Ice Sheet Drilling Program
GMCC	Geophysical Monitoring for Climatic Change
GOES	Geostationary Operational Environmental Satellite (NOAA)
GPCP	Global Precipitation Climatology Project (WCRP)
GPS	Global Positioning System
GRID	Global Resource Information Database
GTCP	Global Tropospheric Chemistry Program
HHS	Department of Health and Human Services
HUD	Department of Housing and Urban Development
ICSOP	Interagency Committee for Stratospheric Ozone Protection
ICSU	International Council of Scientific Unions
IGBP	International Geosphere-Biosphere Program (ICSU)
IGOSS	Integrated Global Ocean Station System (IOC/WMO)

IOC	International Oceanographic Commission (UNESCO)
IODE	International Ocean Data Exchange
IPCC	Intergovernmental Panel on Climate Change
ISCCP	International Satellite Cloud Climatology Project (WCRP)
ISLSCP	International Satellite Land-Surface Climatology Project (WCRP)
JAWF	Joint Agriculture Weather Facility (USDA/NOAA)
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NCDC	National Climatic Data Center
NCP	National Climate Program
NCPO	National Climate Program Office
NO ₂	Nitrous Oxide
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council (NAS)
NSCAT	NASA Scatterometer
NSF	National Science Foundation
NWS	National Weather Service
O ₃	Ozone
OAR	Office of Atmospheric Research
OMB	Office of Management and Budget
OSB	Ocean Studies Board (NAS)
OSTP	Office of Science and Technology Policy
PL	Public Law
R&D	Research and Development
SAGE	Stratospheric Aerosol and Gas Experiment
SAM	Stratospheric Aerosol Monitor
SCOR	Scientific Committee for Ocean Research (ICSU)
SMM	Solar Maximum Mission
SPS	Strategic Planning Seminar (NCP)
STORM	National Storm Operational and Research Meteorology Program
SSM/I	Special Sensor for Microwave/Imaging
TOGA	Tropical Ocean and Global Atmosphere (WCRP)
TOPEX	Ocean Surface Topographic Experiment (NASA)
UARS	Upper Atmosphere Research Satellite
UCAR	University Corporation for Atmospheric Research
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
US	United States
USDA	US Department of Agriculture
USGS	US Geological Survey (DOI)
USSR	Union of Soviet Socialist Republics
VLBI	Very Long Baseline Interferometry
WASDE	World Agriculture Supply and Demand Estimates
WCAP	World Climate Applications Programme (WMO)
WCDP	World Climate Data Programme (WMO)
WCIP	World Climate Impact Studies Programme (UNEP)
WCP	World Climate Program (WMO)
WCRP	World Climate Research Program (WMO/ICSU)
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment (WCRP)
WRI	World Resources Institute
WWW	World Weather Watch (WMO)



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